REGIONAL ENERGY CONSERVATION PLAN FOR TRANSPORTATION

SOUTHEASTERN CONNECTICUT REGION

RECOMMENDED

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SOUTHEASTERN CONNECTICUT REGION

This report was prepared under grant number CT-09-0004(1) from the Urban Transportation Administration of the U.S. Department of Transportation under the Urban Mass Transportation Act of 1964, with a grant from the Connecticut Department of Transportation, and with contributions from the member municipalities of the SCRPA. The findings and recommendations of this report do not necessarily represent the official views or policies of the Connecticut Department of Transportation or the Urban Mass Transportation Administration.

Southeastern Connecticut Regional Planning Agency
139 Boswell Avenue, Norwich, Connecticut

April, 1976

ABSTRACT OF REPORT

1.	Title:	*Recommended Regional Energy Conservation Plan for Transportation, Southeastern Connecticut Region.*
2.	Author:	Southeastern Connecticut Regional Planning Agency, 139 Boswell Avenue, Norwich, Connecticut 06360.
3.	Subject:	Energy conservation in the transportation sector.
4.	Date:	April, 1976.
5.	Name of Agency:	Southeastern Connecticut Regional Planning Agency.
6.	Source of Copies:	Southeastern Connecticut Regional Planning Agency, 139 Boswell Avenue, Norwich, Connecticut 06360.
7.	UMTA Project No.:	CT-09-0004(1).
8.	No. of Pages:	48.
9.	Abstract:	The report reviews the role of transportation in energy use and recommends a five-year staged program to conserve energy through various transportation strategies in the Southeastern Connecticut Region.

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Stephen Wolinski, Griswold
David Wordell, Salem

STAFF ASSISTING IN THE PREPARATION OF THIS REPORT

Richard B. Erickson, Executive Director
Gerhard J. Amt, Assistant Director
Ben Mallick, Transportation Planner (Primary Responsibility for the Report)
Arlene Lewis, Office Manager
Pamela Rivers, Janet Smith, Illustrators
Helen Gahrman, Claire Keroack, Secretaries

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I. INTRODUCTION

In recent decades the automobile has dominated urban transportation in America. This mode represents about 90% of all travel. In consequence, it has been instrumental in shaping life styles, current urban form and particularly the dispersal of the population. Predictably, this dispersed population has become increasingly auto-dependent.

It appears that Americans are not going to revolt against the automobile, at least not in the near future. The average household drives 12,400 miles a year and makes 1,400 trips.* Every day the average household takes 3.8 trips and covers 34 miles.

The low cost of gasoline encouraged unnecessary travel by automobile and drastically reduced the bus system and its ridership. The low cost of petroleum in the world market discouraged domestic production, but yearly increases in the demand for gasoline increased imports and the dependency on foreign oil. In the long run this dependency could leave us in a weakened position, economically and politically.

Planned efforts are required to reduce the overall petroleum demand and at the same time provide better transportation: a critical element of the nation's economy and security.

Urban Mass Transportation Administration regulations require that a staged plan of energy conservation be prepared for any urbanized area receiving federal grants for mass transit. This report has been prepared to satisfy these federal regulations and to contribute toward the national objective of energy conservation.

Statistical information related to commuter habits is seriously lacking for individual regions in Connecticut. Therefore, it is impossible to make precise estimates of those who participate in carpools, the length of carpool trips and the resulting energy being used and conserved. The figures used in this report are best estimates based on the limited available information and should be used with caution. They are indicative rather than precise measures of energy consumption.

This report is concerned only with those aspects of energy related to the transportation sector, and it does not address power generation, home heating and the other areas of energy consumption.

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* "Energy, Land Use and Environment: The Impact on Transit," by Dr. Robert L. Sansom, Transit Journal, November, 1975.

II. ENERGY PERSPECTIVE

The world's petroleum reserves are finite. The United States has no more than 50 billion barrels of proven reserves, and the world-wide reserves are little higher than 700-800 billion barrels.*

Until recently, Americans have freely used and abused our seemingly abundant energy supplies. Energy has been economically exploited rather than economically optimized. On February 29, 1976, the New York Times reported that this country "wasted" as much energy last year as two thirds of the world's population consumed.

One of the most urgent national concerns, and possibly the most pivotal at the present time, is energy consumption. The rising volume of petroleum imports, the experience of a fuel shortage during the Arab oil embargo in late 1973, and probable future shortages of oil supplies make necessary an examination of energy consumption.

In 1960, 20% of the total oil used in the United States was imported.** In 1971, oil imports rose to 25%, and in 1972 reached 29%. By the time of the Arab oil embargo imported oil accounted for 36% of the total oil used in the United States.

Transportation plays a vital role in the national economy. It presently accounts for 20% of the Gross National Product. Transportation alone accounts for 13% of total personal expenditures, and over 40% of the total transportation expenditure is for personal transportation.

Obviously, transportation is also a major consumer of energy. In the transportation sector, energy consumed for the operation of civilian vehicles represents about 24% of total U.S. energy consumption, while military and agricultural vehicles use another 3% of total energy (direct consumption). Manufacturing, maintenance and repair of vehicles and equipment (indirect consumption) accounts for an additional 12%.*** Thus transportation consumes almost 40% of the nation's total energy output.

95% of the energy which transportation uses is petroleum or petroleum based.# It is not surprising, therefore, that the 1973 Arab oil embargo and the subsequent increase in oil prices had such a tremendous effect on the U.S. economy.

Increased efficiency and a reduction in the use of traditional energy sources is needed if the nation is to grow and prosper. Both the government and the public must accept and practice strict conservation practices if the energy situation

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* "Energy Primer: Selected Transportation Topics," U.S. Department of Transportation, 1975, p. 47.

** "Highway Travel Forecasts," U.S. Department of Transportation, Federal Highway Administration, November, 1974, p. 35.

*** "Energy Primer," op. cit., p. 42.

\# "Energy Primer," op. cit., p. 30.

is to improve. The immediate problem requires prompt action. Solutions cannot be left to slow-moving free market mechanisms or to technological breakthroughs. Some strategies for action are presented later in this report.

Along with the need for conservation, there must be a change in the priorities for federal spending within the transportion sector. In F.Y. 1973 the federal government spent some $8 billion on transportation. These expenditures were distributed as follows:*

Highways	- 59%		
Air Transport	- 21%	Mass Transit -	3%
Water Transport	- 15%	Railroads -	2%

In Connecticut in 1974 the transportation sector accounted for about 37.5% of the total energy consumption. All of the energy used for transportation in the state is derived from petroleum. (See Figure 1.)

In Connecticut the transportation energy demand is expected to decrease from 38% in 1975 to 33% of total energy demand in 1995.** It is expected that the energy demand in the industrial sector will increase.

Figure 2 indicates the past and projected trends of transportation energy consumption in the state for motor fuel and other refined products. The graph shows a drop in fuel consumption of about 10.4% between 1970 and 1980 and a drop of 7.5% in other refined projects during the same time period.

The Southeastern Connecticut Region will play a role in the field of energy conservation to help in achieving the state and national energy conservation goals.

III. ENERGY CONSUMPTION AND TRANSPORTATION MODES

DISTRIBUTION OF ENERGY CONSUMPTION

The direct energy consumption in the transportation sector for the movement of people and goods is about 24% of the total energy consumption in the United States. Of this amount, highway transportation is responsible for 76% of consumption, pipelines 5%, aviation 10%, rail and rail transit combined only 4%, and waterways 5%.*** The distribution of consumption in transportation sector for each mode is further analyzed for intercity and urban traffic for passenger and freight in Table 1.

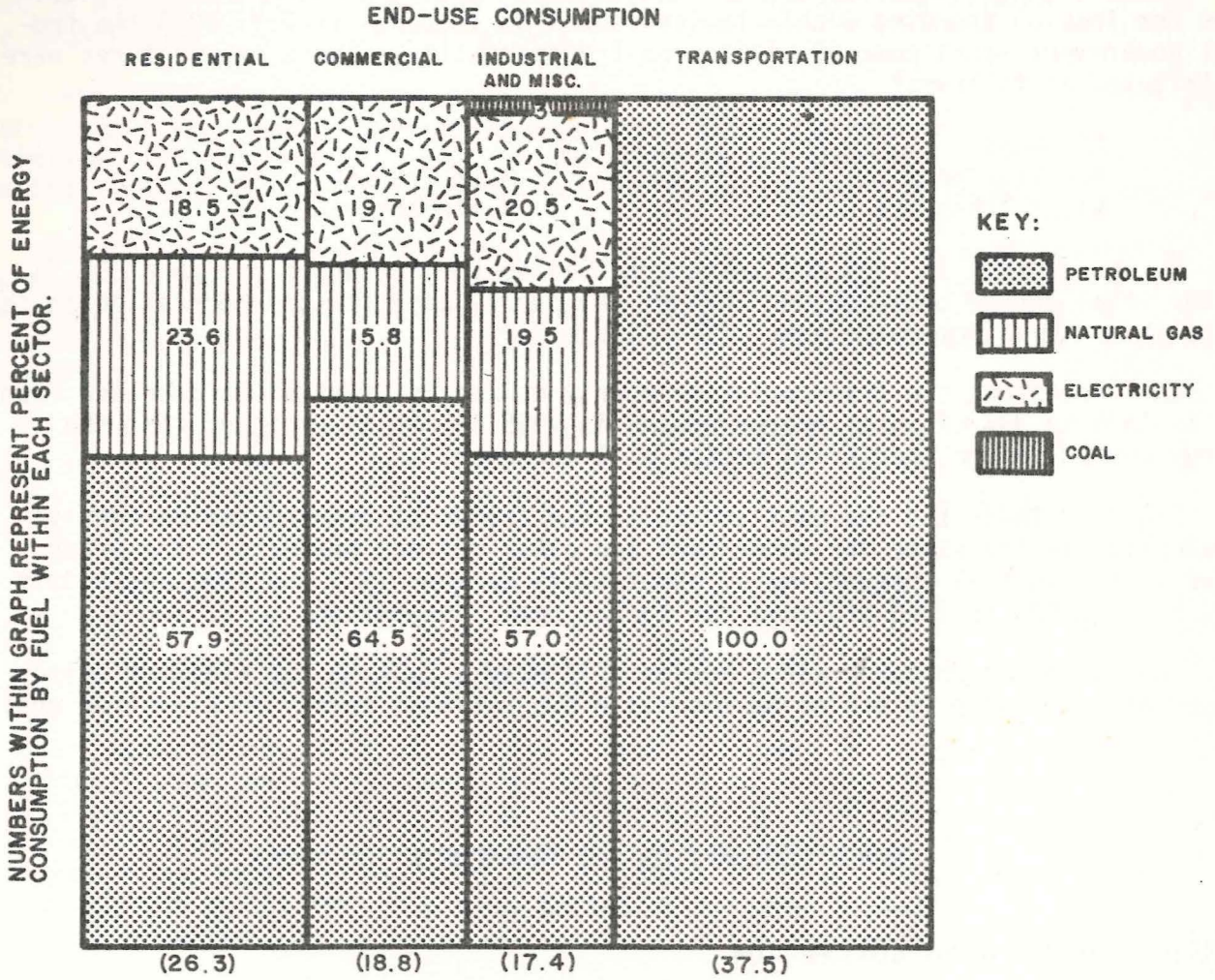
---

* "Transportation Energy Consumption Opportunities and Policy Issues." Eric Hirst. July, 1973.

** "Connecticut Energy Outlook, 1976-1995." Connecticut Energy Advisory Board.

*** "The Public Transportation Investment." Milton J. Pikarsky, Transit Journal, May, 1975.

CONNECTICUT FUEL CONSUMPTION BY SECTOR, 1974

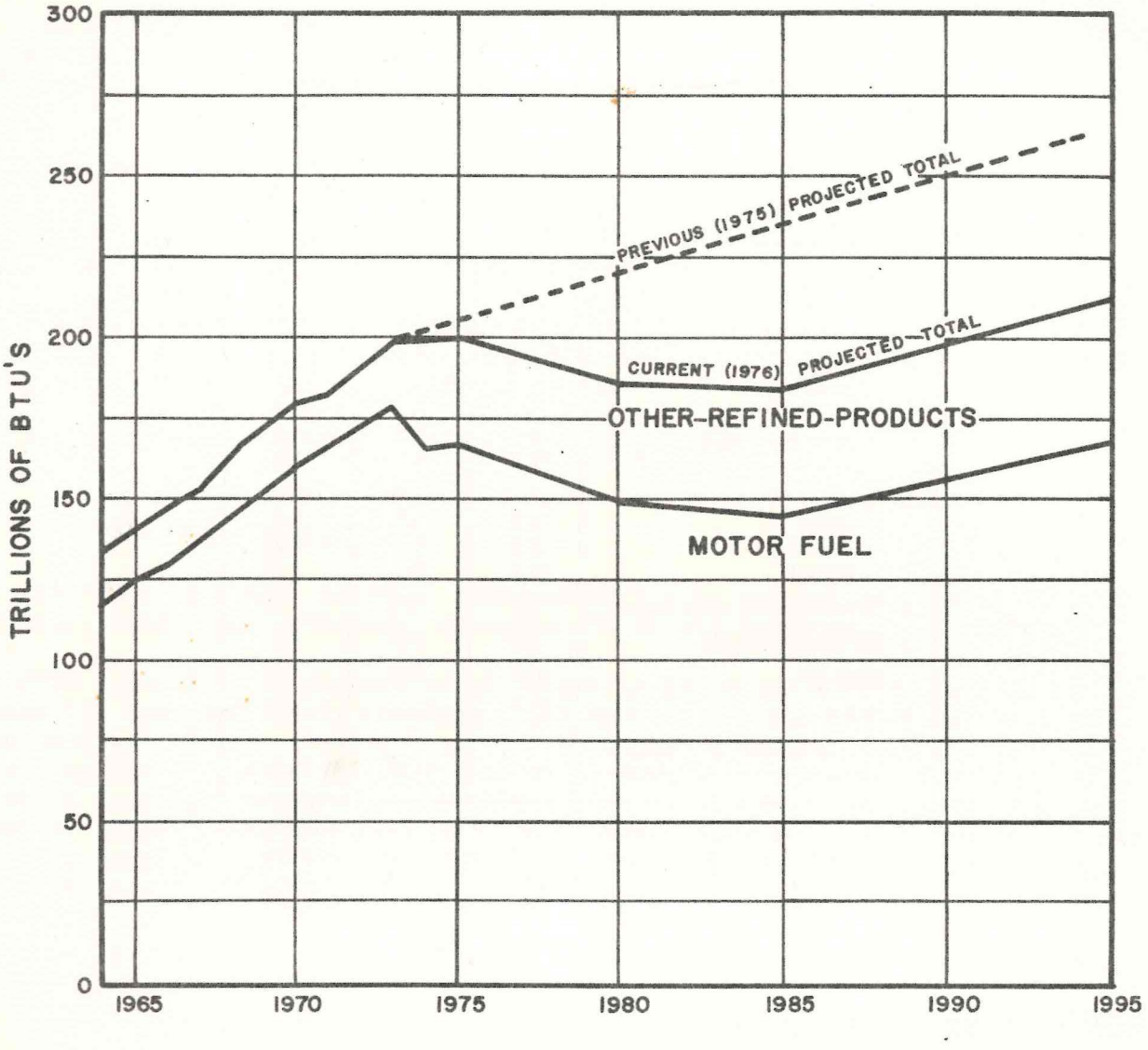


SOURCE: *CEAB, "CONNECTICUT'S ENERGY OUTLOOK, 1976-1995"*

FIGURE 1

Energy consumption per passenger mile is highest for automobiles among the ground transportation modes. However, the energy consumption in airplanes is the highest among all modes of travel, as shown in Table 2. Energy consumption by buses is 1/4 the automobile consumption, whereas railroad per-passenger energy consumption is less than 1/2 the automobile rate.

CONNECTICUT TRANSPORTATION ENERGY CONSUMPTION



SOURCE: *CEAB, "CONNECTICUT'S ENERGY OUTLOOK, 1976-1995"*

FIGURE 2

TABLE 1: DISTRIBUTION OF ENERGY WITHIN THE U.S. TRANSPORTATION SECTOR

	Percent of Total Energy		
	1950	1960	1970
1. Automobiles	(38.0)	(51.4)	(54.2)
urban	22.3	29.2	34.2
intercity	15.7	22.2	20.0
2. Trucks	(16.6)	(19.8)	(21.1)
intercity freight	4.7	7.5	6.9
other	11.9	12.3	14.2
3. Railroads	(25.2)	(4.9)	(3.3)
freight	22.4	4.3	3.1
passenger	2.8	0.6	0.2
4. Airplanes	(1.7)	(7.5)	(10.8)
passenger	0.5	2.0	5.6
freight	0.1	0.3	0.8
general aviation	0.1	0.3	0.6
military	1.0	4.9	3.8
5. Buses	(1.1)	(1.0)	(0.8)
urban	0.8	0.5	0.3
intercity	0.2	0.3	0.25
school	0.1	0.2	0.25
6. Non-bus urban mass transit	1.0	0.3	0.2
7. Waterways, freight	3.6	2.8	2.5
8. Pipelines	0.7	0.9	1.2
9. Other[a]	12.1	11.4	5.9
Total Transportation Energy Consumption[b] (10^{15} Btu)	8.7	10.9	16.5

[a]"Other" (the difference between Bureau of Mines totals and the sum of lines 1-8) includes passenger traffic by boat, pleasure boating, nonfuel uses of energy (lubricants, greases), nonaviation military fuel uses, and errors due to the use of approximations and assumptions.

[b]As reported by the Bureau of Mines.

SOURCE: "Energy Primer," p. 38.

TABLE 2: AVERAGE ENERGY CONSUMPTION BY MODES
(Intercity Passenger Traffic)

Buses	1,090 BTU's/passenger mile.
Railroad	1,700 BTU's/passenger mile.
Automobile	4,250 BTU's/passenger mile.
Airplanes	9,700 BTU's/passenger mile.

SOURCE: "Energy Primer," p. 31.

HIGHWAY ENERGY CONSUMPTION

The energy consumption in various highway modes for the U.S. in 1973 is shown in Table 3.

The average fuel consumption as shown for automobiles is about 13.1 miles per gallon and bus fuel consumption is about 5 miles per gallon. The average fuel consumption in trucks is about 8.45 miles per gallon.

INTERCITY FREIGHT

Intercity freight transportation consumes a significant portion (12%) of the transportation energy budget.* Freight travels by a variety of modes (pipelines, waterways, railroads, trucks and airways) which vary widely both in energy efficiency and in the percentage of total freight-ton-miles carried. The historical trends are shown in Table 4, which indicates the shift of freight from the more energy efficient modes to less efficient ones.

Table 5 presents 1970 U.S. intercity freight data.

INTERCITY PASSENGER TRAFFIC

Intercity passenger traffic, moved primarily by automobiles, but also by airplanes, buses, and railroads, consumes 33% of all transportation energy.**

From 1950-1970 the proportion of intercity passenger traffic carried by automobiles remained fairly constant. Bus and train passenger miles fell, with a concommitant rise in airline traffic. This switch to energy-inefficient air travel was mainly responsible for the 14% decline in the energy efficiency of intercity passenger transportation. This decline and the 130% increase in the volume of traffic together account for a 170% increase in energy consumption for intercity passenger traffic during the last two decades. Table 6 indicates the trends of intercity passenger traffic by mode of travel.

U.S. passenger transportation data for 1970 are shown on Table 7, which indicates various load factors in different intercity and urban modes of transportation.

URBAN PASSENGER TRAFFIC

Urban passenger traffic accounts for another large segment (29%) of transportation energy use: 95.4% of the urban passenger miles travelled are in automobiles, the most energy-intensive (i.e. uneconomical) of all modes. In the last 2 decades the energy consumption by urban passenger traffic grew by 166% due to a decline in energy efficiency of 4.3% and an increase in traffic of 154%.

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* Assumed continuation of current trend.

** "Energy Consumption For Transportation in the United States," Eric Hirst, March, 1972.

TABLE 3: HIGHWAY USE OF MOTOR FUEL, 1973
FIFTY STATES AND DISTRICT OF COLUMBIA

	Passenger vehicles							Cargo vehicles			
	Personal passenger vehicles			Buses							
	Passenger cars	Motor-cycles	All personal passenger vehicles	Commercial	School	All buses	All passenger vehicles	Single-unit trucks	Combi-nations	All trucks	All motor vehicles
Number of vehicles registered (thousands)	101,762	4,356	106,119	89.5	336.0	425.5	106,544	22,205	1,028	23,233	129,777
Average miles traveled per vehicle	9,992	4,498	9,767	28,469	7,178	11,662	9,774	9,868	46,716	11,538	10,083
Fuel consumed (million gallons)	77,619	392	78,011	520	327	847	78,858	22,755	8,860	31,615	110,473
Average fuel consumption per vehicle (gallons)	763	90	736	5,810	973	1,991	741	1,025	8,620	1,361	857
Average miles traveled per gallon of fuel consumed	13.10	50.00	13.29	4.90	7.37	5.86	13.21	9.63	5.42	8.45	11.85

SOURCE: U.S. Department of Transportation, Federal Highway Administration, Highway Statistics, 1973, Table VM-1.

TABLE 4: HISTORICAL TREND OF INTERCITY FREIGHT (PERCENTAGES)

Year	Percent of Total Ton-Miles				
	Railroads	Trucks	Waterways	Pipelines	Airways
1950	57.40	15.80	14.90	11.87	0.03
1955	50.40	17.20	16.70	15.66	0.04
1960	44.70	21.30	16.60	17.34	0.06
1965	43.70	21.70	15.90	18.60	0.10
1970	40.10	21.40	15.90	22.42	0.18
1980*	37.20	21.20	16.20	25.00	0.40
1990*	35.10	21.10	15.10	28.00	0.70

SOURCE: "Energy Primer", p.31.
* Assumed continuation of current trends.

TABLE 5: INTERCITY FREIGHT TRANSPORT DATA FOR 1970

	Actual (BTU/Ton Mile)	Price (Cents/Ton Mile)	Haul Length (miles)	Approximate Speed (mph)
Pipeline	450	0.27	300	5
Railroad	670	1.40	500	20
Waterway	680	0.30	1,000	-
Truck	2,800	7.50	300	40
Airplane	42,000	21.90	1,000	400

SOURCE: "Energy Primer", p.38.

TABLE 6: U.S. HISTORICAL TRENDS OF INTERCITY PASSENGER TRAFFIC

Year	Percent of Total Passenger Miles			
	Automobile	Airplane	Bus	Railroad
1950	86.8	2.0	5.2	6.4
1955	89.5	3.2	3.6	4.0
1960	90.1	4.3	2.5	2.8
1965	88.8	6.3	2.6	1.9
1970	87.0	9.7	2.1	0.9
1980*	85.0	13.0	1.5	0.5
1990*	84.0	15.0	1.0	N.A.

SOURCE: "Energy Primer," p. 32.

* Assumed continuation of current trends.

TABLE 7: U.S. PASSENGER TRANSPORT DATA FOR 1970

	(BTU/Passenger Mile)		Load Factor	Price (cents/	Haul Length	Approx. Speed
	Actual	100% LF	(occupancy)(%)	passenger mile)	(miles)	(mph)
			Intercity			
Bus	1600	740	46	3.6	100	45
Railroad	2900	1100	37	4.0	80	40
Automobile	3400	1600	48	4.0	50	50
Airplane	8400	4100	49	6.0	700	400
			Urban			
Mass transit	3800	760	20	8.3	3	15
Automobile	8100	2300	28	9.6	6	20

SOURCE: "Energy Primer", p. 38.

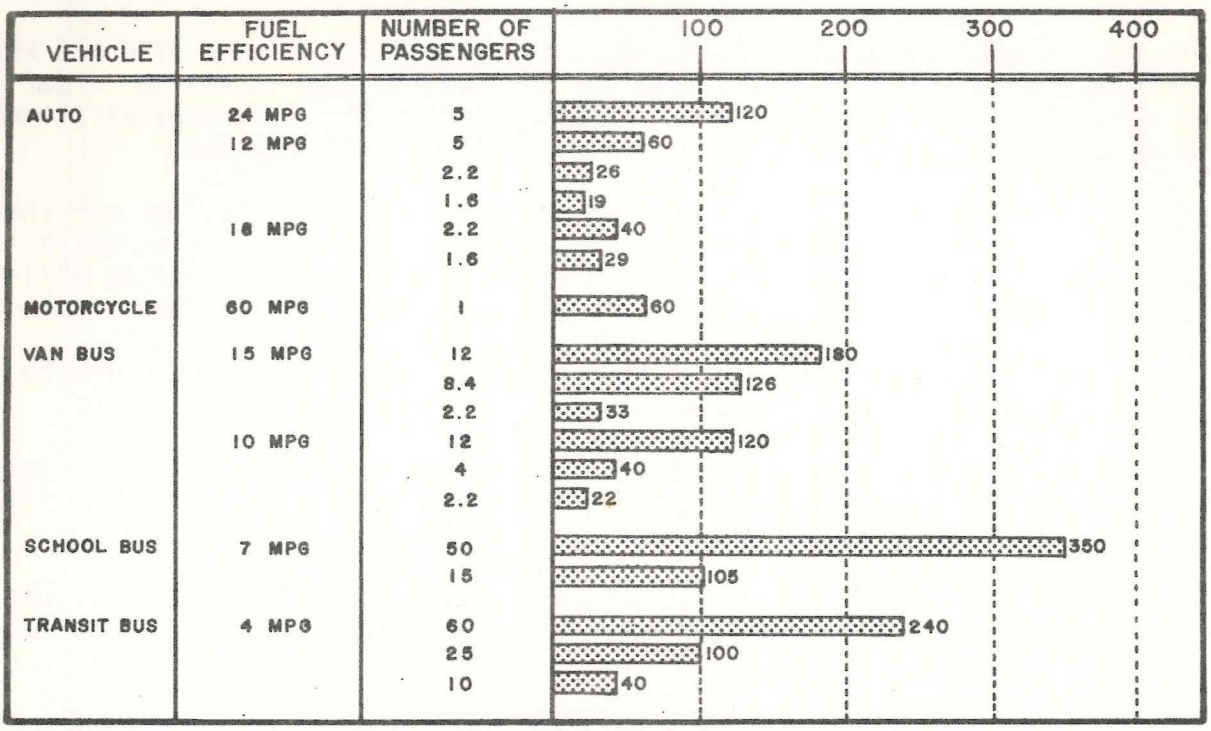
EFFICIENCY OF URBAN COMMUTING MODES

The relative efficiency of urban commuting modes differs widely. Part of this is related to the type of service provided. Figure 3 indicates the relative efficiency of various passenger modes.

Figure 4 compares the energy consumption of private automobiles and mass transit used for commuter purposes within an urban area. As indicated, automobiles consume twice the energy of mass transit during commuter periods.

COMPARATIVE FUEL EFFICIENCY OF VARIOUS MODES OF PASSENGER TRANSPORTATION

VEHICLE	FUEL EFFICIENCY	NUMBER OF PASSENGERS	
AUTO	24 MPG	5	120
	12 MPG	5	60
		2.2	26
		1.6	19
	18 MPG	2.2	40
		1.6	29
MOTORCYCLE	60 MPG	1	60
VAN BUS	15 MPG	12	180
		8.4	126
		2.2	33
	10 MPG	12	120
		4	40
		2.2	22
SCHOOL BUS	7 MPG	50	350
		15	105
TRANSIT BUS	4 MPG	60	240
		25	100
		10	40

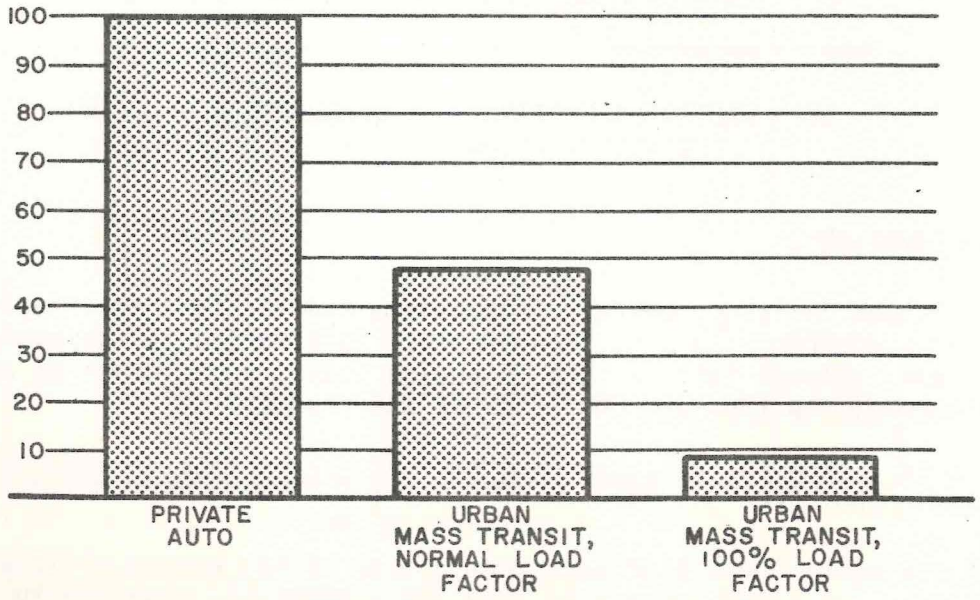


SOURCE: *HIGHWAY STATISTICS DIVISION, FHWA, 1974*

FIGURE 3

RELATIVE ENERGY CONSUMPTION PER COMMUTER FOR INTRAURBAN COMMUTING

(USING 1950–1970 MODAL MIXES)*



**FROM HIRST, E. "ENERGY INTENSIVENESS OF PASSENGER AND FREIGHT TRANSPORTATION MODES."*

FIGURE 4

ANALYSIS

The total energy consumption in the U.S. nearly doubled between 1950 and 1970. The significant role played by transportation in this increase is due to larger volumes of traffic, both passenger and freight, a decline in the energy efficiency of some of the modes, and a shift towards more energy-intensive modes.

Of all the modes of freight transportation, waterways and pipelines are the most efficient. Railroads are the next most energy-economical. Trucks, which have taken over a larger volume of freight traffic, are only one-fourth as efficient as railroads. Airplanes are 60 times more energy-inefficient than trains.

In the same time span (1950-70) energy use by intercity passengers grew by 155%, and urban passenger traffic rose 165%.

The growth of energy consumption by the transportation sector was principally due to the growth in passenger travel, the increase in per capita freight traffic, and energy inefficiencies in the most heavily used modes.

Automobiles and trucks account for 75% of the transportation energy consumption. Thus, modifications in existing automobiles and trucks could save substantial amounts of petroleum.

Various comparison tables indicate railroad and bus modes have the best potential for fuel economy in the under-70-mph speed class. In terms of passenger miles, the automobile and aircraft both have about the same fuel economy. However, factors of convenience, safety, speed, and comfort must also be considered in evaluating a transportation system.

The obvious conclusion that can be drawn from the statistics is that by shifting more passenger trips and freight from high-energy using carriers to low-energy using carriers, a significant contribution can be made to short-term energy conservation objectives.

IV. FACTORS AFFECTING FUEL CONSUMPTION FOR HIGHWAY-RELATED MODES

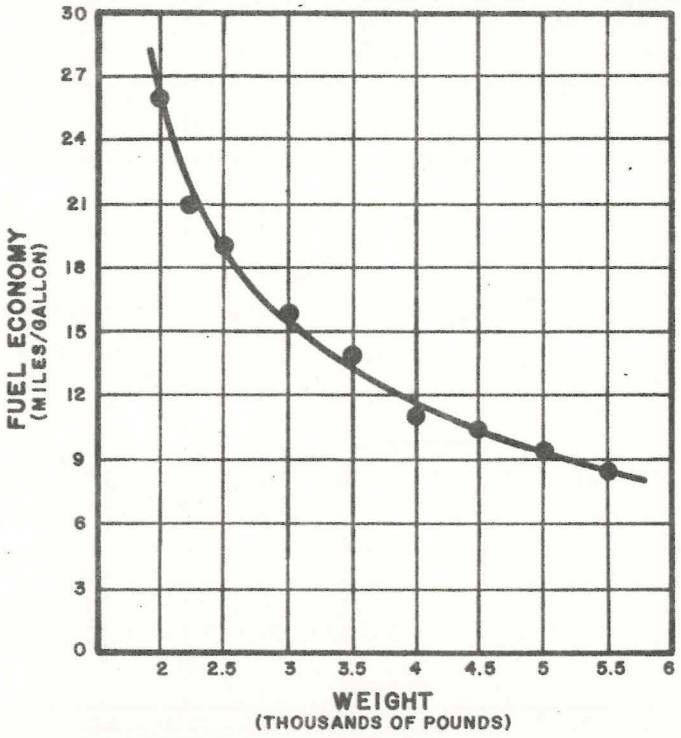
AUTOMOBILE CONSUMPTION

Various factors influence energy consumption, and these differ from one transportation mode to another. This section presents information on the highway-related modes and includes factors such as engine power, vehicle weight and speed, year of manufacture, and type and character of the roadway.

Figures 5 to 7 show the relationships of fuel consumption to vehicle weight, engine size and speed.

Figure 8 indicates the historical trend of decreasing energy efficiency in U.S. automobiles. The trend appears in line for a reversal, however, in view of new federal requirements. Manufacturers will be required to meet the following

FUEL ECONOMY VS. WEIGHT*



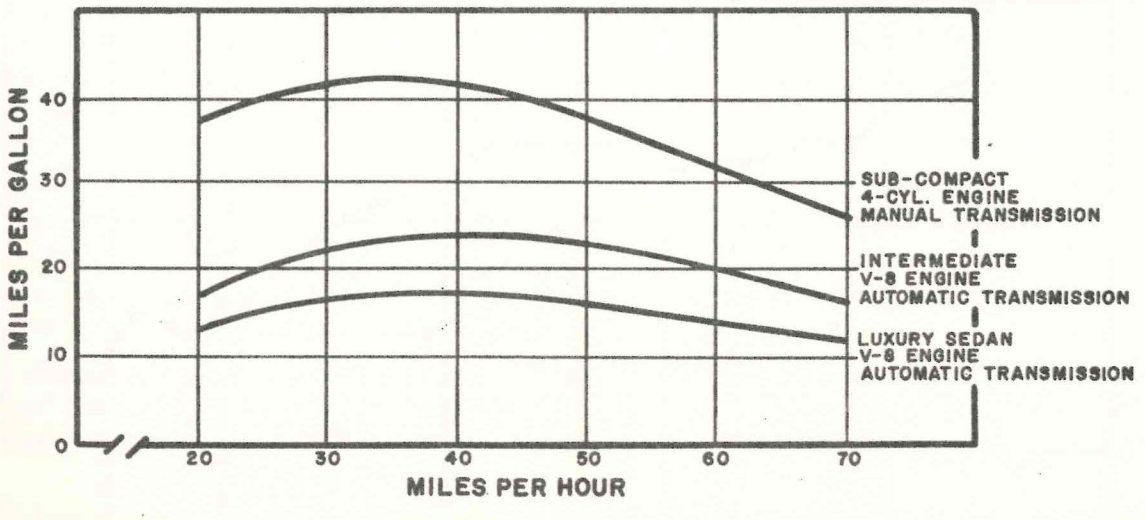
*BASED ON FIGURES FROM THE U.S. EPA OFFICE OF AIR AND WATER PROGRAMS

SOURCE: "GUIDELINES TO REDUCE ENERGY CONSUMPTION THROUGH TRANSPORTATION ACTIONS."

FIGURE 5

ROAD LOAD FUEL ECONOMY

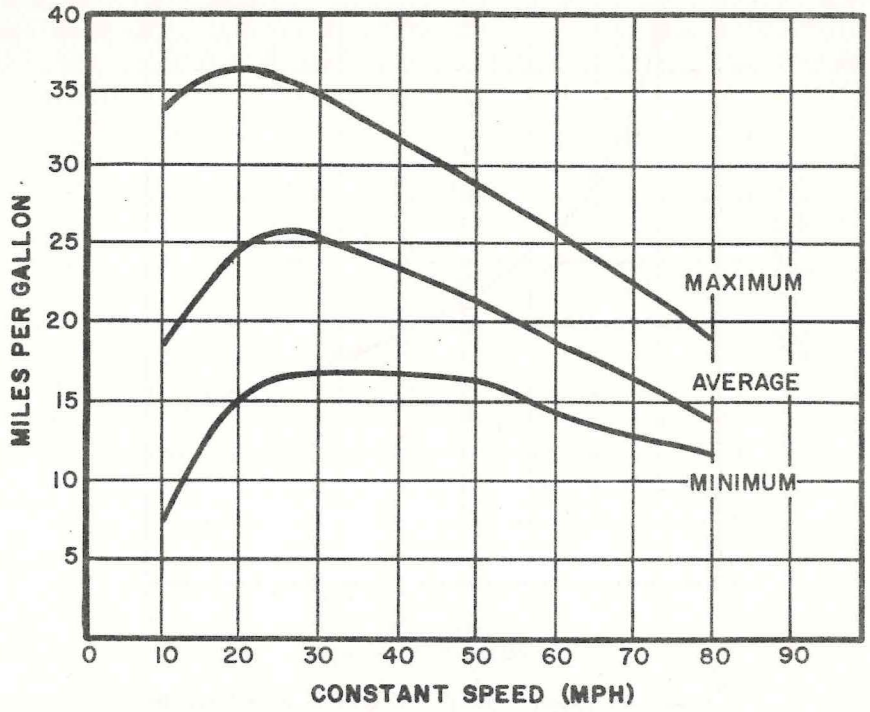
STEADY SPEED OPERATION ON A LEVEL ROAD



SOURCE: G.J. HUEBNER, JR., AND D.J. GASSER, "GENERAL FACTORS AFFECTING VEHICLE FUEL CONSUMPTION"

FIGURE 6

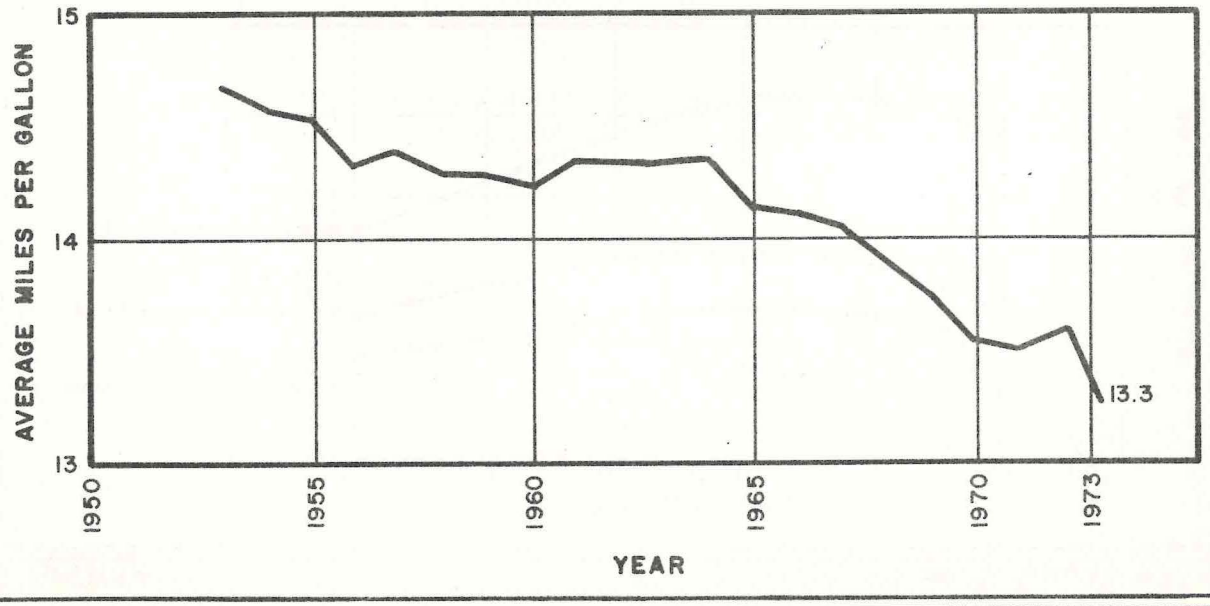
AUTOMOBILE FUEL CONSUMPTION AS A FUNCTION OF SPEED



SOURCE: *"TRAFFIC ENGINEERING HANDBOOK"*

FIGURE 7

AVERAGE FUEL EFFICIENCY OF U.S. PASSENGER CAR FLEET 1953-1973



SOURCE: *FEDERAL HIGHWAY ADMINISTRATION (ANNUAL REPORT), "HIGHWAY STATISTICS"*

FIGURE 8

minimum standards in future automobile energy consumption:* by 1979 - 19 mpg, by 1980 - 20 mpg, by 1985 - 26 mpg.

As shown in Tables 8 and 9, fuel consumption varies according to the type of highway. Consumption per mile is less on a freeway than on an arterial street at comparable speeds, the reason being the complete lack of stop and go operations on a freeway.

TABLE 8: VEHICLE GASOLINE CONSUMPTION ON FREEWAYS

Speed (mph)	Mixed Vehicle(1,3) Consumption (gallons per mile)	Automobile(2,3) Consumption (gallons per mile)
65.0	.09269	.07377
60.0	.08638	.06734
55.0	.08006	.06228
50.0	.07427	.05871
45.0	.07164	.05580
40.0	.07070	.05507
35.0	.06869	.05220
30.0	.06830	.05254
25.0	.06899	.05411

(1) Data based on vehicle mix of 83.04% passenger cars, 6.81% two-ton trucks, 3.26% six-ton trucks, 3.29% twenty-ton trucks, and 3.60% twenty-five ton trucks.

(2) Data based on a vehicle mix of 66% standard and 34% compact automobiles.

(3) Data based on typical roadway segments which reflect various curves, grades, stops per mile, traffic densities, etc.

SOURCES:

Bloom, Kent, TRANS-Urban Computer Model (OPGAS), Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., April, 1973.

Claffey, Paul, "Running Costs of Motor Vehicles as Affected by Road Design and Traffic," NCHRP III, Washington, D.C., 1971.

Federal Highway Administration, TRANS: Fuel Consumption for Urban Freeways and Surface Arterials (Composite Vehicle), U.S. Department of Transportation, Washington, D.C., 1973.

* "Connecticut Energy Outlook, 1976-1995." Connecticut Energy Advisory Board, 1976.

TABLE 9: VEHICLE GASOLINE CONSUMPTION ON ARTERIAL STREETS

Speed (mph)	Mixed Vehicle[1,3] Consumption (gallons per mile)	Automobile[2,3] Consumption (gallons per mile)
40.0	.09326	.07998
35.0	.09312	.07970
30.0	.09497	.08054
25.0	.09428	.07993
20.0	.09102	.07742
15.0	.09244	.07842

(1) Data based on vehicle mix of 83.04% passenger cars, 6.81% two-ton trucks, 3.26% six-ton trucks, 3.29% twenty-ton trucks, and 3.60% twenty-five ton trucks.

(2) Data based on a vehicle mix of 66% standard and 34% compact automobiles.

(3) Data based on typical roadway segments which reflect various curves, grades, stops per mile, traffic densities, etc.

SOURCES:

Bloom, Kent, TRANS-Urban Computer Model (OPGAS), Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., April, 1973.

Claffey, Paul, "Running Costs of Motor Vehicles as Affected by Road Design and Traffic," NCHRP III, Washington, D.C., 1971.

Federal Highway Administration, TRANS: Fuel Consumption for Urban Freeways and Surface Arterials (Composite Vehicle), U.S. Department of Transportation, Washington, D.C., 1973.

BUS CONSUMPTION

Table 10 shows fuel consumption at various speeds for different bus sizes.

VEHICLE OPERATING COST

Vehicle operating costs vary due to several factors. Table 11 indicates how operating costs are affected by speed and type of highway.

Figure 9 indicates the relationship of the estimated annual operation costs of different types of automobiles for their first and second years of operation.

TABLE 10: FUEL CONSUMPTION FOR BUSES
(gallons per vehicle-mile)

Vehicle Speed (mph)	Fuel Consumption on Level Roadway		
	Minibus (1)	Midsize (2)	Large (3)
5	0.437	0.222	0.446
10	0.474	0.128	0.251
15	0.266	0.105	0.193
20	0.134	0.091	0.167
25	0.139	0.078	0.156
30	0.149	0.072	0.154
35	0.158	0.079	0.095
40	0.168	0.082	0.108
45	0.119	0.089	0.123

(1) Above data based on standard GMC Van equipped with 12 seats and a gasoline engine (Model 366).

(2) Above data based on midsize GMC 33-seat passenger bus equipped with a diesel engine (DH 478).

(3) Data based on standard GMC 51-seat passenger bus equipped with standard diesel engine (6Y71N/C5I).

SOURCE: General Motors Corporation Truck and Coach Division, "Vehicle Dynamics Simulation Model," Pontiac, Michigan, 1974.

V. REGIONAL TRENDS AND ENERGY CONSUMPTION

In general, transportation system trends in the Southeastern Connecticut Region reflect average U.S. trends for the movement of passengers and goods, with the exception of air travel.

CAR REGISTRATION

Automobile registration increased by nearly 14% between 1970-74 in this region. However, there was a marked slowdown in the rate of increase in 1974. It is difficult to predict future trends of registration; however, for the purpose of this report it is assumed that existing trends will continue. (See Figure 10.)

TABLE 11: VEHICLE OPERATING COST IN 1973

Speed (mph)	Cost (cents per mile) on Freeway	Cost (cents per mile) on Arterial Streets
60	12.74	-
55	11.88	-
50	11.27	-
45	10.66	-
40	10.23	-
35	9.92	17.03
30	9.68	16.17
25	9.56	15.99
20	-	15.44
15	-	14.58

NOTES: Data is in terms of 1973 costs; includes maintenance, tires, oil, gasoline, and depreciation, but excludes taxes, insurance, parking, and tolls.

SOURCE: Bloom, Kent, TRANS-Urban Computer Model (OPGAS), Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., April, 1973.

Cost data based on a vehicle mix which includes trucks and private automobiles: 83.05% passenger cars, 6.8% two-ton trucks, 3.26% six-ton trucks, 3.29% 20-ton trucks, and 3.60% 25-ton trucks.

Data based on typical roadway segments which reflect various curves, grades, stops per mile, traffic densities, etc.

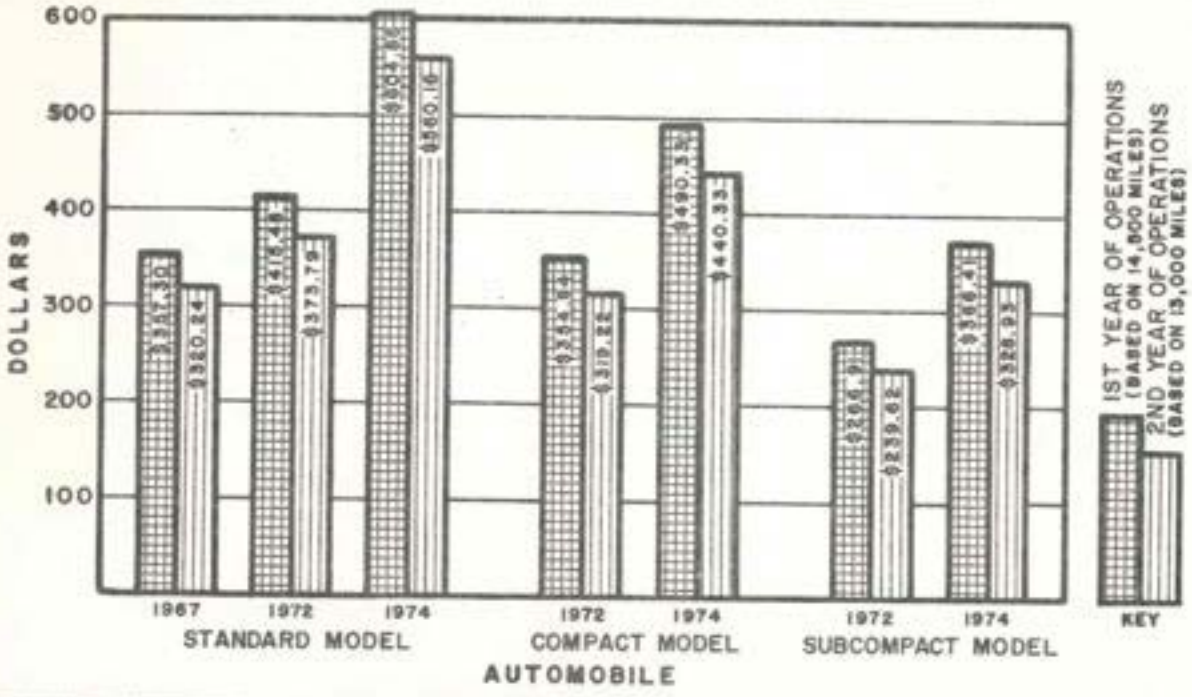
CAR OCCUPANCY

Various estimates of car occupancy, based on actual surveys and models, were first developed for this region by the State Department of Transportation. New estimates of car occupancy for the various purposes of travel were developed by SCRPA. The car occupancy rate, as indicated by the 1970 Census data for journey to work, is 1.20 for Southeastern Connecticut. Occupancy factors for 1970 are compared to 1962 data in Table 12.

TRIP LENGTH

The length of individual trips made by vehicles is an important aspect of urban travel. Estimated trips for various purposes and average trip lengths for 1970 and 1980 are shown in Table 13.

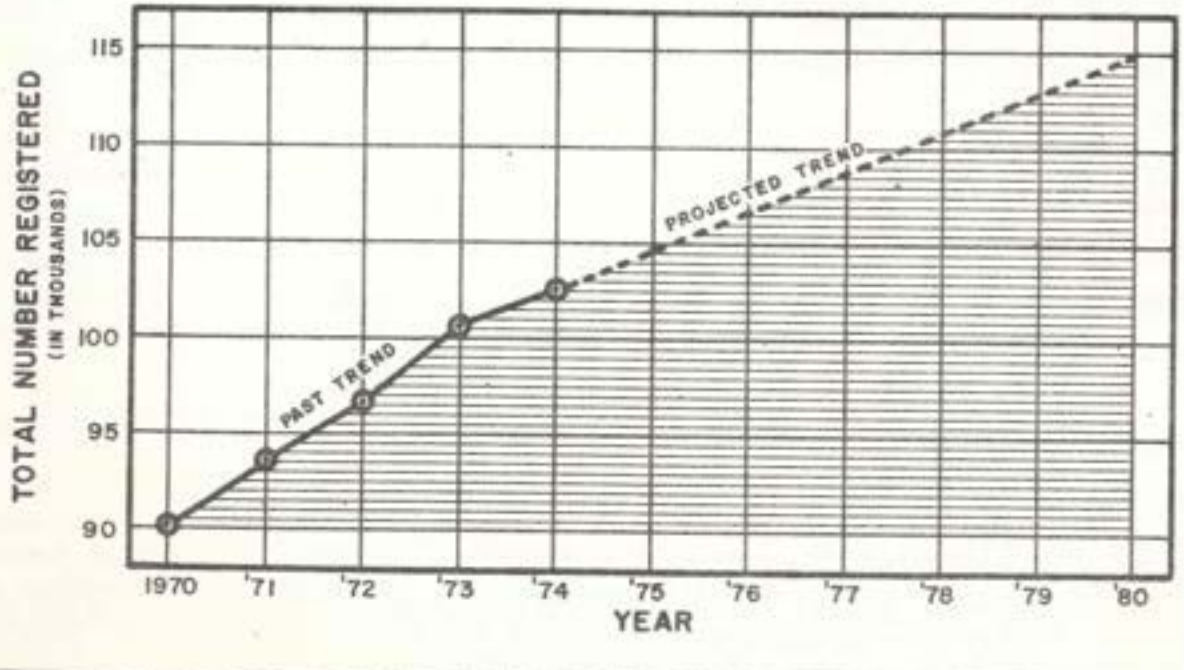
ESTIMATED ANNUAL AUTOMOBILE GASOLINE AND OIL COSTS INCLUDING TAXES, BY SIZE AND YEAR OF OPERATION



SOURCE: *HIGHWAY STATISTICS DIVISION, FHWA, 1974*

FIGURE 9

TRENDS IN AUTOMOBILE REGISTRATION
SOUTHEASTERN CONNECTICUT REGION



SOURCE: *BASED ON DATA PROVIDED BY CONNDOT*

FIGURE 10

TABLE 12: AVERAGE CAR OCCUPANCY, 1962 AND 1970

Trip Purpose	Occupancy 1962	1970
Work Trips, Home-based	1.46	1.20
Long Trips, Home-based	2.10	2.10
Short Trips, Home-based	1.99	1.65
Non-Home-based Trips	1.82	1.70
Average for All Trips	1.81	1.65

SOURCE: 1962 data from CONNDOT and 1970 data estimated by SCRPA.

TABLE 13: AVERAGE TRIP LENGTHS (ATL) - SOUTHEASTERN CONNECTICUT

Purpose	Trip Productions	ATL Minutes	ATL Miles
	1970		
Work, Home-based	79,662	15.0	8.4
Long, Home-based	41,968	16.7	10.5
Short, Home-based	127,341	9.0	4.9
Non-home based	95,035	11.7	6.4
Truck	34,301	13.4	8.1
All Trips:	378,307	12.3	7.0
	1980		
Work, Home-based	92,876	15.3	8.9
Long, Home-based	51,228	17.5	10.9
Short, Home-based	168,750	9.1	5.1
Non-home based	123,414	12.0	6.8
Truck	50,208	14.1	8.9
All Trips:	486,476	12.5	7.3

SOURCE: Based on statewide data provided by CONNDOT.

The average trip length for vehicle travel for 1970 was 7.0 miles and is expected to increase to 7.3 miles by 1980.

AUTO AND PERSON TRAVEL - 1980

Daily automobile and passenger vehicle travel were projected through the application of trip generation methodology, employing various factors. The projected automobile and person trips for 1980 for various purposes are shown on Table 14 and Figure 11.

TABLE 14: DAILY AUTO AND PERSON TRIPS, 1980

Southeastern Connecticut Planning Region

Trip Purpose	Number of Auto Trips	Percentage of Total Trips	Occupancy Factors	Number of Person Trips	Percentage of Person Trips
Work, Home-based	92,876	21.3	1.20	111,451	15.7
Long, Home-based	51,228	11.7	2.10	107,579	15.2
Short, Home-based	168,750	38.7	1.65	278,437	39.4
Non-home-based	123,414	28.3	1.70	209,804	29.7
TOTAL:	436,268	100.0	1.65	707,271	100.0

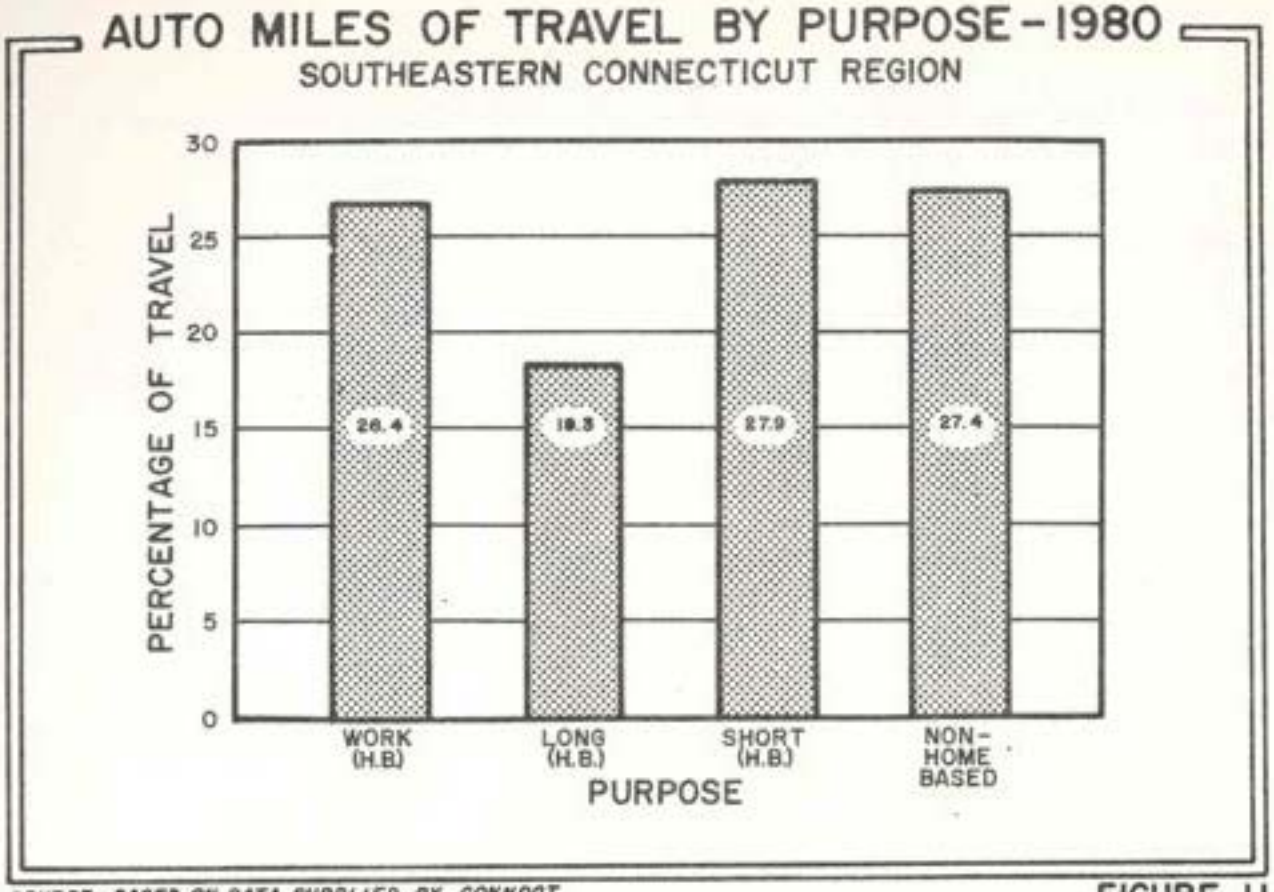
SOURCE: Based on CONNDOT Statewide Projections.

AUTO AND PASSENGER MILES OF TRAVEL

Daily auto and passenger miles of travel are shown on Table 15. Significantly, this table indicates that for work trips the percentage of vehicle miles of travel is higher than the percentage of passenger miles of travel, due to the low occupancy of vehicles and greater trip length for that trip purpose.

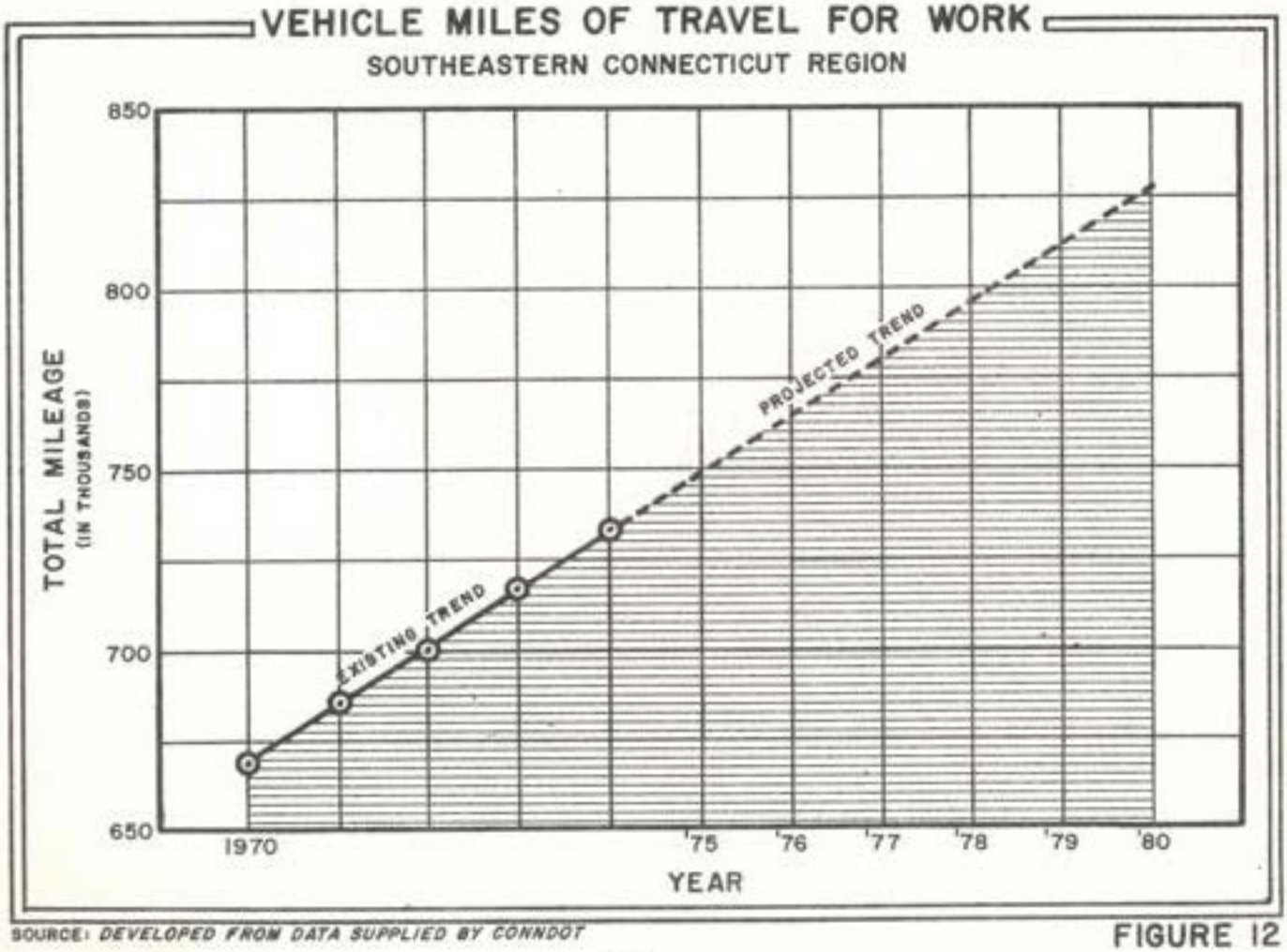
PROJECTED VEHICLE MILES OF TRAVEL FOR WORK

The assumed trend of vehicle miles of travel for the remainder of this decade is shown in Figure 12. The projected automobile miles of travel for work purposes is shown in Table 16. The almost constant percentage increase in auto mileage for this purpose can be altered by energy-saving practices, such as carpooling and commuter busing. These and other options will be discussed later in this report.



SOURCE: *BASED ON DATA SUPPLIED BY CONNDOT*

FIGURE 11



SOURCE: *DEVELOPED FROM DATA SUPPLIED BY CONNDOT*

FIGURE 12

TABLE 15: DAILY AUTO AND PASSENGER MILES OF TRAVEL, 1980

Purpose	Number of Trips	Average Trip Length	Auto Vehicle Miles of Travel	% of Total Auto Travel	Occupancy Factor*	Passenger Miles of Travel	% of Total Auto Passenger Miles
Work, Home Based	92,876	8.9	826,596	26.8	1.20	991,914	19.8
Long, Home Based	51,228	10.9	558,385	18.1	2.1	1,172,611	23.4
Short, Home Based	168,750	5.1	860,625	27.9	1.65	1,420,029	28.3
Non-Home Based	123,414	6.8	839,215	27.2	1.7	1,426,667	28.5
TOTAL:	436,268	7.0	3,084,821	100.0	1.65	5,011,221	100.0

* Assumed continuation of existing trends.

TABLE 16: PROJECTED DAILY AUTOMOBILE VEHICLE-MILES OF TRAVEL FOR WORK

Southeastern Connecticut Region

Year	Vehicle-Miles of Travel For Work	Percentage Increase
1975	748,000	-
1976	764,000	2.1
1977	780,000	2.1
1978	796,000	2.2
1979	811,000	1.9
1980*	826,596	1.9

* Assumed continuation of existing trends. The 1980 figures are calculated projections of the past trend, while other figures have been read from the graphic representation on Figure 12.

TRUCK TRAVEL

Truck travel was derived from the trip generation models developed by CONNDOT. Projected daily truck trips and vehicle miles are available, but no data are available about the average freight tonnage for each mile of vehicle travel.

The projections indicate that in 1980 there will be 50,208 average daily truck trips, in Southeastern Connecticut, each trip averaging 8.9 miles, for a total of 446,851 vehicle miles.

REGIONAL ENERGY CONSUMPTION - 1980

Energy consumption data concerning auto travel for home based work, long, short, and non-home based purposes are shown in Table 17 for the year 1980. The calculations of energy consumption were based on previous trends, without considering the impact of various actions such as carpooling or transit.

Projections of energy consumption from 1975 to 1980 are shown on Table 18. The increase in energy consumption is approximately 2% per year. This figure is close to the national travel projection of a 2% increase per year. Table 19 indicates yearly consumption for various purposes of travel of home-based and non-home-based trips.

COMMUTER PARKING FACILITIES

CONNDOT initiated a major commuter parking facilities program in 1974 in response to gasoline shortages, the spiraling costs of commuting to work, and the

TABLE 17: DAILY ENERGY CONSUMPTION FOR AUTOMOBILE TRAVEL, 1980*

Southeastern Connecticut Region

Purpose	Vehicle Miles	Average Fuel Consumption in Gallons (15 mpg)	% of Total Consumption
Work, Home-based	826,596	55,106	26.8
Long, Home-based	558,385	37,226	18.1
Short, Home-based	860,625	57,375	27.9
Non-Home-based	839,215	55,947	27.2
TOTAL:	3,084,821	205,654	100.0

* If previous trends continue.

growing traffic congestion in employment centers. A total of 16 commuter parking lots has been established in this region to date, providing 947 parking spaces. Table 20 provides data on the existing lots. SCRPA has proposed additional lots throughout the region. Figure 13 shows the locations of the existing and proposed commuter parking facilities.

CARPOOLING

In the last few years the Connecticut State Department of Transportation has conducted a carpool matching program under the Governor's three point program: to reduce fuel consumption, traffic congestion and air pollution. In July, 1973, CONNDOT offered assistance in establishing carpools to private industries having 1,000 or more employees. In addition to the major employer program, an areawide sponsorship program with automobile clubs, news media, radio stations, chambers of commerce, regional planning agencies, the Connecticut Business and Industry Association, and CONNDOT was initiated. SCRPA played an important role in cooperating with CONNDOT in their carpool matching program for this region.

To meet the needs of carpoolers, the interchange commuter parking facilities program was initiated, as described previously.

CONNDOT has also encouraged carpooling by offering carpoolers reduced prices for commuter toll ticket books on the Connecticut Turnpike. Carpoolers may purchase a book of 42 tickets for $1.00, compared to a regular price of $3.50. The only stipulation for usage of carpool tickets is that the vehicle must contain at least three persons when it passes through a toll plaza. Carpool tickets cost slightly more than 2 cents per use, compared with about 8 cents per ticket for regular commuter tickets. Obviously, both offer considerable savings compared

TABLE 18: DAILY ENERGY CONSUMPTION PROJECTED TRENDS FOR AUTOMOBILE TRAVEL TO WORK FOR SOUTHEASTERN CONNECTICUT REGION

Year	Vehicle Miles	Energy Consumption In Gallons*	Percentage of Increase
1975	748,000	49,866	-
1976	764,000	50,933	2.1
1977	780,000	52,000	2.1
1978	796,000	53,066	2.2
1979	811,000	54,066	1.9
1980	826,596	55,106	1.9

* Average consumption assumes 15 mpg.

TABLE 19: DAILY AUTOMOBILE ENERGY CONSUMPTION PROJECTED TRENDS FOR SOUTHEASTERN CONNECTICUT REGION

Purpose of Trips	Energy Consumption In Gallons					
	1975	1976	1977	1978	1979	1980
Work, Home Based	49,866	50,933	52,000	53,066	54,066	55,106
Long, Home Based	33,678	34,399	35,119	35,839	36,514	37,226
Short, Home Based	51,913	53,023	54,134	55,244	56,285	57,375
Non-Home Based	50,610	51,693	52,776	53,857	54,873	55,947
TOTAL:	186,067	190,048	194,029	198,006	201,738	205,654

NOTES: Assumes existing trends of percentage of travel by purpose.
Assumes previous trends of auto occupancy.

to the regular toll charge of 25 cents. All commuter tickets are good for a 60-day period, including the date of purchase, and are valid at the toll plazas at which they were purchased plus up to two other stations in either direction.

TABLE 20: COMMUTER PARKING LOTS

Southeastern Connecticut Region, 1975

Town	Location	Lot Capacity	Estimated Usage (%)
Bozrah	Jct. Route 2 and Route 163 and SR. 612, Exit 19	12	50
Colchester	Jct. Route 2 and Route 149	39	25
Colchester	Jct. Route 2 and Route 16	20	79
Colchester	Jct. Route 2 and Route 11, SR. 637	60	63
East Lyme	Jct. I-95 and Route 161, Exit 74	50	100
East Lyme	Rte. 161, off maintenance garage drive	20	4
Griswold	Jct. Route 52 and SR. 629 and Route 138, Exit 85	96	32
New London	Jct. I-95 and State Pier Road	100	N.A.
North Stonington	Jct. I-95 and Routes 216 and SR. 626	45	44
Norwich	Jct. Route 52 and West Town Street, Exit 82	115	73
Norwich	Jct. Route 52 and Route 82, Exit 80	97	58
Norwich	Jct. Route 52 and Route 97	60	69
Preston	Jct. Route 2A and Route 12	36	N.A.
Stonington	Jct. Route 1 and North Main Street	41	7
Stonington	Jct. Route 2 and Route 78	96	8
Waterford	Jct. Route 52 and Route 85, Exit 77	60	26
TOTAL:		947	

SOURCE: CONNDOT status report for week ending 12 December 1975.

Both regular and carpool commuter ticket sales at the Montville Toll Station on Route 52 increased during the first year of the reduced price program. (The program was initiated in March, 1974.) Second quarter 1974 sales of regular tickets were 6,386, compared with 8,182 for the same period in 1975. Carpool ticket sales grew from 324 in the second quarter of 1974 to 487 for the same period in 1975.

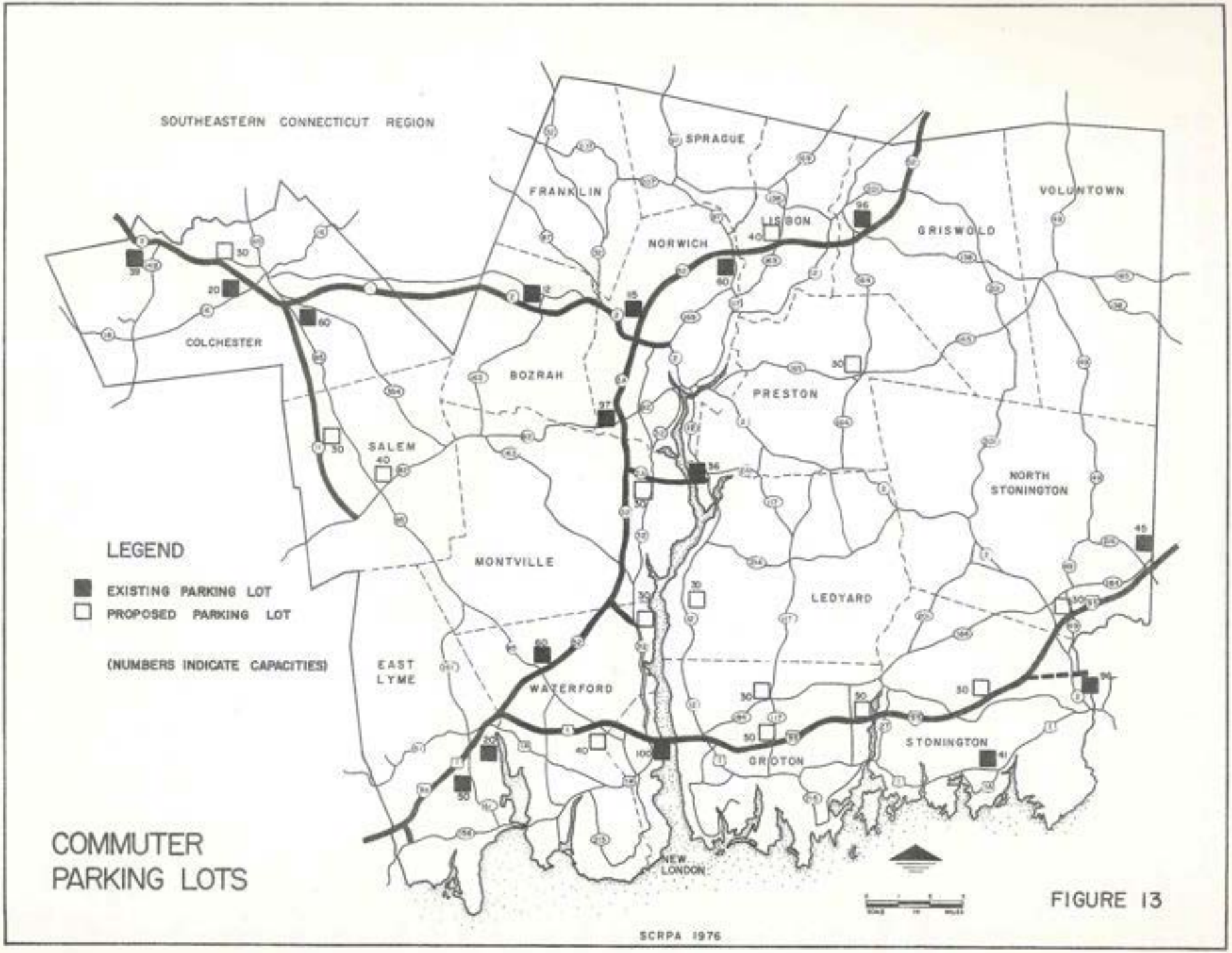

SOUTHEASTERN CONNECTICUT REGION
SPRAGUE
FRANKLIN
LISBON
NORWICH
GRISWOLD
VOLUNTOWN
COLCHESTER
BOZRAH
PRESTON
SALEM
NORTH STONINGTON
MONTVILLE
LEDYARD
EAST LYME
WATERFORD
GROTON
STONINGTON
NEW LONDON
LEGEND
EXISTING PARKING LOT
PROPOSED PARKING LOT
(NUMBERS INDICATE CAPACITIES)
COMMUTER PARKING LOTS
SCRPA 1976

FIGURE 13

A recent CONNDOT survey revealed that the average trip length of carpooling commuters who leave their cars at the commuter parking lots is 27 miles one way. Commuters using lots in the Norwich area traveled 40 miles one way.

For purposes of analysis an average trip length of 27 miles for users of the parking lots will be assumed for this region. Applying the statewide average of 58% usage of spaces in commuter parking lots, the number of cars occupying spaces on an average day totals 549. This translates to 29,646 vehicle-miles saved each day, or, based on an average performance of 15 miles per gallon, a savings of 1,976 gallons of gasoline per day.

Another measure of carpooling effectiveness is the results of a telephone survey conducted by SCRPA in March, 1976. Seven major employers in the region were contacted for information regarding the extent of carpooling among their employees. The results of the survey are presented in Table 21. This data and the preceding discussion on commuter parking lots are not intended to represent a total picture of current energy conservation effectiveness. They do provide a good indication of how significant savings can be realized by carpooling.

TABLE 21: CARPOOLING EFFECTIVENESS IN SELECTED AREA INDUSTRIES, 1976
SOUTHEASTERN CONNECTICUT REGION

Employer	Number of People Carpooling	Average Occupancy	Average Trip Length in Miles	Savings in Auto-Miles	Daily Gasoline Savings in Gallons
Electric Boat, Groton	6,500	4	12	97,503	6,500
Pfizer, Groton	200*	3	10	2,220	148
U.S. Navy Base, Groton	1,027	3	16	18,272	1,218
Underwater Systems Center, New London	750	3	12	10,008	667
King-Seeley Thermos Co., Norwich	300	3	12	4,008	267
Federal Paper Board, Sprague	30	3	10	320	21
TOTAL:	8,807	-	-	~~19,801~~ 132,331	8,821

SOURCE: SCRPA Telephone Survey. March, 1976.

NOTE: 1970 Work trip auto occupancy factor of 1.2 has been taken into consideration.
* Approximate

ENERGY SAVINGS FROM EXISTING COMMUTER BUSES

Approximately 500 Electric Boat employees in Groton travel to work on commuter buses.* The average trip length of these commuters is about 20 miles. Assuming a fuel consumption rate of five miles per gallon for the buses, an average occupancy of 40 passengers per bus and efficiency of 15 miles per gallon for commuter automobiles, with 1.2 as the occupancy factor, the fuel saving for bus commuters amounts to about 1,000 gallons per day. Actual savings depend on the exact number of trips the buses make.

ENERGY SAVINGS FROM EXISTING TRANSIT SERVICE

New London:

The average number of passengers transported daily in New London is 232 and the bus vehicle miles are 186.** The average trip length is 4 miles. It was found that if these passengers traveled by car (1.65 occupancy factor) fuel consumption would be the same, with no savings for either mode. This indicates poor ridership, as far as fuel economy is concerned.

Norwich:

In Norwich the average daily passenger ridership is 200 with 180 miles of bus travel.** Assuming an average trip length of 3 miles and car occupancy of 1.65 persons, the fuel savings are minimal. Fuel economies on these local systems will not be realized until ridership increases.

TAXIS AND PARATRANSIT

Several taxi operations are presently being carried on in Southeastern Connecticut. In addition, a number of social action organizations provide vans or similar vehicles for transporting elderly and handicapped people.

At the present time there is no central source of statistical data for this region that would permit a uniform and comprehensive evaluation of the efficiency of either taxis or other forms of paratransit in terms of their energy consumption, although some information on the area's taxi services is available from the state Public Utilities Control Authority. It is not known whether these forms of transportation operate at less efficiency or cost than the private automobile, reduce energy consumption by increasing vehicle occupancy factors, or whether they offer mobility to persons who might otherwise simply not be traveling as much.

It is felt that the special characteristics of taxis and other paratransit must be more fully understood before their role in meeting the overall transit needs of the region can be determined. Only then can their energy conservation aspects be properly evaluated. To this end SCRPA has initiated a data gathering effort aimed at acquiring complete and current information on the extent of these

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* Carpool Office, Electric Boat, Groton.

** Thomas Kirker, Regional Transit Manager, CONNDOT.

forms of transportation and enabling an assessment to be made of their efficiency as related both to the needs of society and to energy conservation. For the above reasons, this report makes no evaluation of or recommendations concerning taxis and other forms of paratransit.

VI. TRANSPORTATION STRATEGIES AND PLAN OF ENERGY CONSERVATION

STRATEGIES

To meet the energy shortage we must either increase the supply of energy by developing new technologies, use the available energy more efficiently, or do both. This report focuses on the second approach: use energy more efficiently in the transportation sector.

The following five strategies are found to be applicable in the Southeastern Connecticut Region for the purpose of achieving short-term energy conservation in the field of transportation.

A. Use the existing transportation systems more efficiently by increasing the load factor of vehicles.

B. Shift trips from less efficient modes to more efficient modes.

C. Make highway systems more efficient for the flow of traffic.

D. Encourage technology aimed at improving energy efficiency (e.g. smaller cars).

E. Reduce travel demands.

Each of these strategies is examined in more detail on the following pages.

A. Increasing the Load Factor

The energy efficiency of a mode may be improved by increasing the load factor (occupancy). Increasing the number of persons moved per vehicle mile or vehicle trip is one approach toward reducing urban vehicle miles of travel. The load factor in private automobiles may be increased by sharing their use through carpooling.

Increasing load factors of freight-hauling common carriers would be easier to do since the Interstate Commerce Commission already regulates this sytem to a large extent. By prioritizing loads, less important cargos could be held until full loads are achieved before releasing for movement.

Statistics indicate that fuel consumption by automobiles varies considerably according to trip purpose. However, the load factor influences the efficiency of the automobile. Automobiles are least efficient when used for commuting, where the average load factor is 1.22 occupants per car.* The automobile is considered the most economical when used for intercity vacation trips, when the average load factor is 3.3** occupants per car.

At the present time some employees within Southeastern Connecticut are being encouraged to join a van pool program. The program was started recently by the Southern New England Telephone Company in New London and is a good example in this region.

The advantages of carpooling and van pooling are that they make better use of existing vehicle passenger capacity. They offer service tailored to meet the door to door direct transportation needs of commuters and can be organized and operated with a minimum of formality. More carpool, van pool, and bus pool programs should be encouraged in this region.

This strategy can be implemented with less official efforts and fiscal resources than the other strategies. It is a simple and achievable action which offers the possibility of considerable energy conservation, especially in the short-range.

B. Modal Shifts

Alternative modes to the heavy energy-consuming automobile must be found. Many ideas have been advanced as alternatives to commuting by automobile. They include express commuter bus service, urban mass transit, carpooling, bicycling, and walking.

Shifting auto traffic to public transit is a potential fuel economy measure. In the Southeastern Connecticut Region a substantial portion of travel to and from major centers of work has the potential of being carried by buses.

This diversion is limited chiefly by the number of buses that can be made available. The longer time involved and public acceptance are also problems. However, educating the public to the facts that buses are safer, less fatiguing and less expensive may influence the ridership.

Bicycling and walking have limited potential in reducing the total vehicle miles of travel. But bicycling can be a useful mode during summer months in areas where the terrain is flat.

Rail is more energy-efficient than trucking, using only one-fourth as much fuel per ton mile. Shifting more intercity freight to rail can save fuel. Rail capacity is sufficient to handle the likely increased load, but terminal facilities and piggyback cars are limited. At present rail freight is suitable only for longer distances since it takes more time.

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* "Regional Transportation Plan," SCRPA, Table 30.

** "Energy and Environmental Aspect of U.S. Transportation," Energy Primer, op. cit., page 4.

C. Efficiency of the Highway System and Traffic Control

The efficiency of the highway system and traffic controls are important influences on vehicle fuel consumption.

Speed is one of the most important factors. The optimum fuel economy for most cars occurs at a steady speed of between 20 and 40 miles per hour. Thus energy can be saved by either decreasing from high speeds or increasing speeds from low levels. For example, cruising at 50 mph instead of 70 mph results in a savings of about 25%.*

Acceleration/deceleration and stop/go cycles result in increased fuel consumption. The steadier and more continuous the speed, the more fuel is conserved.

Table 22 indicates the additional operating and time cost of stopping and returning to initial speed. (The cost of idling for a traffic signal to change was not considered.) About 90% of the operating cost can be assumed to be for the additional consumption of fuel.

TABLE 22: ADDITIONAL OPERATING AND TIME COST OF STOPPING AND RETURNING TO INITIAL SPEED

Initial Speed	Operating Cost (Dollars per 1000 Stops)		Time Cost (Dollars per 1000 Stops)	
	Passenger Cars	Commercial Vehicles	Passenger Cars	Commercial Vehicles
15	3.26	9.30	4.76	9.50
20	4.95	14.15	5.71	12.60
25	6.96	20.11	6.69	15.86
30	9.36	27.39	7.74	19.27
35	12.24	36.26	8.86	22.94
40	15.76	47.12	10.05	26.97
45	19.99	60.12	11.41	31.50
50	25.15	76.06	13.13	36.87
55	31.43	94.91	15.44	43.78
60	39.09	117.44	18.73	53.64

SOURCE: "At Grade Versus Grade Separate Interchanges," by Kenneth R. Agent, published in Traffic Engineering, June, 1975.

* "Guidelines to Reduce Energy Consumption," UMTA, May, 1974, page A-49.

Stop-and-go cycles result in increased fuel consumption, both from acceleration/deceleration and from idling. The average car consumes about 0.6 gallons per hour when idling. As an example of the composite effect of a stop-and-go cycle, one cycle per mile from a 30 mph level with 30 seconds of idling, results in 20-30% extra gallons of gasoline consumed.

From the above it can be deduced that unnecessary or uncoordinated traffic signals and toll booths result in increased fuel consumption and cost. Improper traffic lights and uncoordinated signals waste fuel, add to pollution and congestion, and aggravate drivers.

Toll booths, too, are an expense to society, directly and indirectly. They create an imbalance in the distribution of traffic over the region's highways. The Montville Toll Station on the Connecticut Turnpike (Route 52) is a good example of creating an imbalance in the distribution of traffic. The Connecticut Turnpike carries much less traffic than parallel Route 32, whereas the Turnpike has twice the carrying capacity of Route 32.

Data supplied by the CONNDOT for the Montville Toll Station for the year 1975 indicates gross revenues of $776,978 and net revenues of $442,245 after expenditures.

The SCRPA analysis* indicates that the total cost to the travelling public in 1975 was $776,978 in direct tolls plus an additional operating and lost time cost of about $192,300 resulting from the acceleration and deceleration and time lost in stopping at the toll booth. The cost of idling has not been considered. In addition, stop and go traffic at the toll booth resulted in wasting about 211,800 gallons of fuel. Considering both the direct and indirect public cost, the efficiency of collecting revenue at this toll booth was 45.1%. This means if the cost to the public were $100 in tolls plus additional operating and lost time costs, the net revenues to government were $45.10. In addition, the toll booth results in a substantial waste of fuel.

The gross receipt of revenues for the Mohegan-Pequot Bridge on Route 2A for 1975 were $319,982, and the net revenues were $9,795 after expenditures.

The results of the analysis by SCRPA indicate that in 1975 the costs to the travelling public were $319,982 for direct toll charges plus additional operating and time costs of about $97,300 (the cost of idling has not been added) and wastage of approximately 101,600 gallons of gasoline. The efficiency of this toll booth was 2.3%, i.e., for every $100 of direct and indirect cost to the public the net government revenues were $2.30, after expenses. In addition, a significant amount of gasoline was wasted.

From the above toll booth analysis it can be deduced that toll booths are not an efficient means of tax collection. Toll booths cause imbalances in traffic patterns. This creates congestion on parallel non-toll arteries, thus requiring additional capital expenditure to reduce congestion on those highways, such as Route 32, and under use of toll highways, such as Route 52. Further, toll booths create stop and go driving conditions that are very wasteful of gasoline.

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* See the Appendix for a detailed review of this analysis.

Uncoordinated and unnecessary signals at various locations in the region create congestion and additional fuel consumption. Fixed traffic signals, are wasteful of energy, due to changing traffic conditions from hour to hour and day to day.

There is a need for the removal of tolls, adjustment in signal times, new traffic control and management systems, synchronization of signals, removal of unwanted signals, turning lanes, more occasions where a right turn is permitted on a red signal after stopping, and improvements in the geometrics of intersections. Traffic control measures like these will not eliminate all inefficient fuel use, they they can effect additional savings.

D. Encourage Technology for Improved Energy Efficiency

Automobile fuel economy is very low and presently offers a great opportunity for improvement through technology. One means of improving energy efficiency is by reducing power demand, which can be achieved in the following ways:

1. Encourage smaller, lighter-weight vehicles. Fuel economy is directly related vehicle weight.

2. Improving auto body design to reduce aero-dynamic drag would reduce energy consumption. The demand on power to operate automobile accessories also consumes energy and is an area where conservation practices are needed.

3. Another means of conserving energy is to increase the efficiency of the propulsion system itself. A new engine currently under study holds some promise of achieving this. Alternative sources of fuel, such as electricity, are becoming more widely used in automobiles and buses. Public transit authorities should be alert to the possible use of such vehicles in this region.

E. Reduction In Travel Demand

Reducing the need for personal travel is a factor which can save a large amount of transportation energy. This strategy is the most difficult to implement, as it affects the American life style. However, this strategy may prove most useful in the long-term. The following are some methods of reducing travel demands.

1. Four-day Work Week. There is some doubt that this can reduce the vehicle miles of travel. It will certainly decrease the vehicle miles of travel for work, but it may encourage some people to travel longer distances for recreation, as presently happens during long weekends. The latter may be offset by high gasoline prices which could discourage people from traveling long distances.

2. Land Use Planning. This could be a most effective means of reducing travel. The locations of place of work and place of living need to be coordinated. If people live closer to their work place, they can either walk or use bicycles to go to work. Planning for housing, shopping facilities and employment activities must be more closely integrated. At present, each tends to be looked at separately and planned for independently.

3. Communication Substitution. Many studies suggest that high capacity audio-video channels may be used to reduce the need for travel. However, it is not likely that audio-video communication will encourage land use patterns which reduce travel demands. Human face to face contact is an essential element in many communications for which it is difficult to substitute. It is doubtful that communication systems can substantially reduce vehicle miles of travel, at least in the near future.

4. Home Deliveries. The practice of having dairy and other food products delivered to the home declined as the private automobile increased personel mobility. This was the case until gasoline prices began to rise dramatically.

Home deliveries would not effect a substantial reduction in fuel consumption in the rural and suburban parts of the region, but in the more urbanized areas where delivery trips are shorter, some fuel savings could be realized.

PLAN OF ENERGY CONSERVATION

A. Fuel Savings from Travel to Work

Improving carpooling and commuter express bus service are the two major actions which can lead to substantial savings of energy for travel to work (the only major trips where fuel savings can be effected). Table 23 indicates that fuel savings could be increased from 23% in 1975 to 37% in 1980 of the fuel that would be consumed for travel to work without any conservation.

Carpooling: The previous analysis indicates that energy conservation can be achieved through more efficient use of the existing transportation system. Since the automobile will continue as the dominant transportation mode for the near future, greater effort should be made to use this mode more efficiently. Carpooling appears to offer the potential of substantial fuel savings, especially with regard to work trips.

Table 21 shows the savings from current major employer initiated carpooling programs. In the absence of complete data, it is assumed that commuters who park at the commuter parking lots are not those shown on Table 21. The savings from commuter parking lots have been added separately to the overall carpool savings. At the same time, individual carpool/van pools were not included to compensate for the overlap.

In 1975 the total estimated savings from carpooling is about 10,800 gallons of gasoline per day (Table 23). These savings represent a reduction of 21% in the total fuel consumption for travel to work by automobile. Projections of work travel indicate that there will be about a 2% increase in travel every year as indicated in Table 16. To keep pace with the increase in travel for work, efforts in carpooling have to be stepped up to absorb that increase and to achieve additional savings. Keeping in view the practical constraints of carpool programs, we estimate that up to a maximum of 32% of the fuel consumption for travel to work could be saved by 1980, as shown in Table 23.

TABLE 23: PROJECTED DAILY FUEL SAVINGS FOR SOUTHEASTERN CONNECTICUT

	Fuel Savings From Travel To Work							Fuel Savings From Non-Work Travel		Savings From Traffic Operations Improvements		Total Fuel Savings	
	Carpooling		Commutor Bus		Total		% Reduction In Total Auto Fuel Consumption For All Purposes	Bus Transit					
Year	Gallons	%*	Gallons	%*	Gallons	%*		Gallons	% Reduction In Total Auto Fuel Consumption For All Purposes	Gallons	% Reduction In Total Auto Fuel Consumption For All Purposes	Gallons	% Reduction In Total Auto Fuel Consumption For All Purposes+
1975	10,800	21	1,000	2	11,800	23	6	0	0	0	0	11,800	6
1976	11,200	22	1,000	2**	12,200	24	6	0	0	380	0	12,580	6
1977	13,000	25	1,800	3	14,800	28	7	180	#	780	#	15,760	8
1978	14,900	28	1,800	3	16,700	31	8	770	#	1,200	0.6	18,670	9
1979	16,200	30	2,600	5	18,800	35	9	770	#	1,600	0.8	21,170	10
1980	17,600	32	2,600	5	20,200	37	10	780	#	2,060	1	23,040	11

* % reduction in total fuel consumed by travel to work.
** Assumes no increase in service but a yearly increase in travel to work.
\# Less than 0.5%
\+ Rounded to nearest full percentage point.

It is impossible to calculate exact energy savings through carpooling programs without a detailed survey and continuous monitoring. Therefore, these figures must be used with caution. They are useful in judging the relative effectiveness of various strategies and actions.

Commuter Bus Service: Shifting a portion of the auto-commuters to commuter express buses also has great potential. Substantial energy savings are expected to be achieved with the staged implementation of commuter bus service in Southeastern Connecticut as recommended in the Regional Transportation Plan.

Analysis indicates that the present savings are about 1,000 gallons a day from the Electric Boat program. The Regional Transportation Plan recommends that 6 buses on each of its four corridors of travel, Connecticut Routes 12, 32, and 156 and U.S. Route 1, be operated by 1980. It is assumed that principally these buses will run during peak hours in the mornings and evenings at 10-minute frequency, transporting about 4,000 passenger trips every day. Assuming an average trip length of 10 miles, this will save about 1,600 gallons of fuel every day by 1980. This service will be in addition to the existing commuter bus service run by private operators. Given the adverse financial situation of the state, it is assumed that this service will be implemented in two stages. The service may be started as early as in 1977. The fuel savings from the commuter bus service are expected to be about 2% in 1975 and 5% by 1980 of the total that would be consumed for travel to work without this conservation effort. (See Table 23.)

B. Fuel Savings From Non-Work Travel

The five-year Transit Development Program prepared in 1975 by SCRPA has indicated the need for the improvement of transit facilities. The implementation of the Transit Development Program will result in reductions in fuel consumption as indicated in Table 23.

The five-year Transit Development Program estimated a ridership of 5,090 passenger trips on an average weekday by 1980. With an average trip length of 7 miles for each passenger, an estimated savings of about 780 gallons of fuel a day could be achieved by 1980 (Table 23), which will be about 0.4% of the projected total daily auto fuel consumption in the region in 1980 without conservation measures. These savings are based on the assumption that these passenger trips are shifted from automobile to bus. However, actual savings may be different. From the above analysis it can be deduced that the estimated ridership on the transit system has only limited impact on energy savings. There will be a significant savings only if the actual ridership in buses increases from the level now estimated.

C. Fuel Savings From Various Traffic Operations Improvement

Traffic operations improvements on the region's highways can contribute toward fuel savings. The traffic operations improvements include eleminiation of unnecessary traffic control devices, widening intersections for turning lanes, adjustment of signal times, right turn on red traffic light, etc. It is almost impossible to calculate the exact amount of savings that can be derived from such

actions. However, a report published for the Urban Mass Transportation Administration indicates a regional energy reduction of 1 to 4% for various traffic operations improvements.*

To be more realistic about traffic operations improvements that could be accomplished by 1980, it is assumed that a reduction of at least 1% in the total energy consumption for transportation could be achieved in this region by 1980. This could result in a daily fuel saving of more than 2,000 gallons. (See Table 23.)

D. Energy Conservation - 1980

Table 23 shows a potential for saving about 23,000 gallons of fuel every day through various actions. It indicates that by 1980 conservation efforts could reduce gasoline consumption by 11% from the level that would exist without such efforts. The fuel savings from other actions than those shown on Table 23 have not been included due to the lack of any basis for estimating. The projected fuel savings for the region compare favorably with the state's energy savings projections in "Connecticut Energy Outlook, 1976-1995," prepared by the Connecticut Energy Advisory Board.

VII. STRATEGY IMPLEMENTATION AND IMPACTS

Transportation actions which can be implemented in a short time to reduce energy consumption should consider the availability of resources, administrative and legislative aspects plus the direct and indirect socio-economic and environmental impacts. The various actions which can be implemented to achieve the goals of energy conservation are described below.

A. Strategy - Increasing The Load Factor

Car/van Pools

Voluntary carpooling program should be encouraged through greater public informational programs on radio and television, in newspapers, and through meeting with private groups and business and industry.

- Positive incentives should be given to the carpoolers by providing more public parking spaces. State-sponsored commuter parking lots should be constructed in accordance with the recommendations in Figure 13 of this report.

- Employers in the region should encourage carpools for their employees and should reserve parking for carpoolers. Government should expand its assistance

* "Guidelines to Reduce Energy Consumption Through Transportation Actions," by Alan M. Voorhees and Associates, Inc., May, 1974.

to employers in establishing and promoting carpooling programs.

- Ownership of a second family car should be discouraged by increasing the taxes and the cost of registration on second cars. This would require action by the state legislature.

- Increasing the gasoline tax would encourage carpooling and pay for carpooling incentive programs. This would also require action by the state legislature.

Impacts

Socioeconomic: Carpooling would reduce transportation costs for the average family, thus providing money for other family expenses. However, mobility and travel convenience are reduced. Mental fatigue from driving is reduced, which may have a beneficial effect on productivity. Social interaction with fellow travelers would certainly be increased.

Environmental: Reductions in traffic noise, congestion and air quality will be directly related to the amount of carpooling achieved. Increasing the occupancy of automobiles should decrease the amount of land required to be paved over for parking lots.

B. Strategy - Mode Shift

Encourage Mass Transit

There is a great need to expand bus transit facilities and increase transit ridership. The following actions are recommended.

- Expand local bus service and provide extensive commuter bus service through the Southeastern Connecticut Transit District.

- A detailed plan should be prepared jointly by CONNDOT and the affected Regional Planning Agencies for the establishment of interregional express commuter bus service to major employment centers.

- Frequent and reliable service, especially at peak hours, should be provided throughout the urbanized area of the region, in accordance with the region's Transit Development Program.

- Improve the public's awareness of bus services, fares, schedules, and routes through a vigorous marketing effort, conducted by the Southeastern Connecticut Transit District.

- Encourage a shift from auto travel to bus through an aggressive promotional campaign, by SCRPA and the Regional Transit District, using employers, employee groups, merchants' associations, local officials, and voluntary organizations to publicize the availability of transit.

- Provide special bus service during summer months to beaches or tourist attractions in or near the urbanized area. This service should be provided through the Regional Transit District.

- The Regional Transit District should provide special bus stop shelters, preferably heated during winter months.

- Park-n-ride and kiss-n-ride facilities should be constructed along commuter bus routes to encourage people to park and ride the commuter bus or to permit the spouse to leave the commuter at the bus stop. This program should be developed jointly by CONNDOT and the Regional Transit District.

- Employers should charge employees for parking spaces or provide a partial reimbursement of employees' commuter bus fares to encourage people to ride buses. Encouraging implementation of this recommendation should be the joint responsibility of CONNDOT and the Regional Transit District.

- Merchants should be encouraged to reimburse bus fares to patrons who travel to their stores by bus and make a minimum purchase. Assistance to achieve this should be provided by CONNDOT and the Regional Transit District.

Encourage Walking and Bicycle Modes

Greater efforts should be made to make people aware of the benefits of walking and bicycling. The following measures are recommended.

- Municipalities should provide safe facilities for pedestrians and cyclists through the construction of wide sidewalks or separate lanes for cycles.

- Promote the health and conservation aspects of walking and bike riding through schools and voluntary organizations.

- Local planning commissions should consider requiring facilities for pedestrians and cyclists in newly developing areas under their jurisdiction.

Impacts

Socioeconomic:

- Bus riders will have more social interaction with fellow passengers.

- The elderly, the young and the handicapped will experience new or expanded mobility.

- More bus riders will create less dependency on foreign oil.

- Property values are likely to increase on bus route corridors.

Environmental:

- Walking and bicycle riding are generally healthy activities, but doing so along some highways may be unhealthy, due to emissions from motor vehicles.

- An increase in walking, cycling and bus ridership should reduce vehicle miles of travel and hence reduce noise and air pollution levels.

C. Strategy - Highway Efficiency Through Traffic Operations and Management

Decrease Stop-And-Go Situations

Fuel consumption is closely related to the smoothness of traffic flow. The following actions are aimed at permitting traffic to maintain steady speeds, where possible, and encouraging the most appropriate routes of travel in the region. Most of these actions are traffic operations improvements and may be partially funded under state and federal highway safety funding programs.

- Removal of tolls would encourage travel on Routes 52 and 2A which will result in more fuel savings and relieve congestion on Route 32. The legislature should take appropriate action to remove the tolls from the Connecticut Turnpike in Montville and the Mohegan-Pequot Bridge. This action would encourage greater use of these presently under-used facilities and would relieve congestion on alternate routes.

- Turning right on red traffic signals, after stopping, should be permitted at a much greater number of intersections. Municipalities should initiate studies in cooperation with CONNDOT to identify those intersections most suited to this arrangement.

- Unnecessary traffic signals should be removed, and all traffic signals should be synchronized. Timed signals should reflect the changing need of traffic over the day. In off-peak hours traffic lights could function just as flashing lights at intersections where off-peak traffic is light. This is a municipal and CONNDOT responsibility.

- Where practical, municipalities and CONNDOT should provide turning lanes to avoid unnecessary idling.

Impacts

Socioeconomic:

- The flow of traffic on some highways would improve, saving travel time, energy and cost.

- Reduced idling at intersections will make more efficient use of auto fuel and lessen the cost to drivers.

- The removal of tolls would reduce the need for major widening improvements on other highways such as Route 32.

- These traffic operations improvements should reduce accidents.

Environmental:

- Less acceleration and deceleration will significantly reduce air pollution and noise in specific locations.

D. Strategy - Encourage More Energy-Efficient Technology

Technological improvements in automobile designs that result in less fuel consumption per mile should be pursued vigorously. Such improvements concern vehicle size and weight, engine efficiency, and aerodynamic considerations in body design, such as smaller, lighter cars. While it is recognized that these improvements are important and could ultimately have the effect of reducing energy consumption nationwide, there is little that can be done within Southeastern Connecticut directly to influence technological changes.

E. Strategy - Reduce The Need For Travel

Providing alternative modes of travel and making more efficient use of existing modes can result in substantial energy savings, but long-term significant reductions in transportation related energy consumption depend on an overall reduction in the need for traveling in the first place. The following are some actions aimed at implementing this basic strategy.

Land Use Controls

- Local planning and zoning should have as a primary objective the reduction of the dependence upon automotive transportation to travel from homes to schools, shopping, recreation, work and frequently used governmental and institutional centers. Responsible local boards and commissions should periodically review local development plans to determine if such objectives are being achieved and should review all proposals for new development with these objectives in mind.

Home Delivery of Goods

- Phone-order and mail-order shopping, coupled with home delivery of merchandise can reduce travel needs. Positive action by merchants is needed to achieve this. Many people currently shop by phone or mail during the Christmas season. An expansion of this activity throughout other parts of the year should be encouraged.

Short Work Week

- Encouraging a four-day work week has been suggested as a means of reducing travel and generally conserving energy. Such action should be approached with caution, however, if the reduced work trips are simply replaced by more frequent or longer recreation trips during the resulting increased leisure time.

Impacts

Socioeconomic:

- Reducing travel needs should leave more time for social and civic activities, resulting in greater involvement of people in institutional and governmental affairs.

- With less time spent for travel, families would have more time to spend together, thus strengthening the family institution.

Environmental:

- Reducing the need for travel would substantially reduce noise and pollution caused by traffic and would conserve energy otherwise consumed by vehicles.

- A more efficient use of land would result, providing a better opportunity to preserve sensitive natural areas. Certainly, less land would be paved over for parking lots.

APPENDIX

ANALYSIS OF THE INDIRECT COST AND ENERGY CONSUMPTION EFFECTS OF TOLL BOOTHS

1. Montville Toll Station, Route 52, 1975

A. Basic Data.

(1) Traffic:

Passenger Cars	3,423,682	
Commercial Vehicles	231,332	
Total:	3,655,014	

(2) Gross Revenue: $766,978

(3) Expenditures:

a. Operational Costs

Personnel	$275,617	
Contract Services	43,014	
Supplies	7,006	
Subtotal:	$325,637	

b. Maintenance Costs

Personnel	$ 7,527	
Contract Services	460	
Supplies	1,109	
Subtotal:	$ 9,096	
TOTAL EXPENDITURES:		$334,733

(4) Net Revenue: $432,245

B. Analysis of Indirect Costs to the Public.

(1) Passenger Cars:

a. Costs Per Vehicle Stop From 55 MPH:

Operation	3.14 cents
Lost time	1.54 cents
Total:	4.68 cents

b. Calculation of Indirect Cost:

Operation:	3,423,682 stops x $0.0314 =	$107,504
Lost Time:	3,423,682 stops x $0.0154 =	52,725
Total Indirect Cost:		$160,229

c. Calculation of Gasoline Wasted in Stopping:

- It is assumed that 90% of the operating cost is for gasoline.
- It is assumed that the average price of gasoline is 55 cents per gallon.

$107,504 x 0.9 ÷ $0.55 = 175,916 gallons

(2) Commercial Vehicles:

a. Costs Per Vehicle Stop From 55 MPH:

Operation	9.49 cents
Lost Time	4.37 cents
Total:	13.86 cents

b. Calculation of Indirect Cost:

Operation:	231,332 stops x $0.0949 =	$21,953
Lost Time:	231,332 stops x $0.437 -	10,109
Total Indirect Cost:		$32,062

c. Calculation of Gasoline Wasted in Stopping:

- For purposes of estimation, all commercial vehicles are assumed to be fueled by gasoline.
- It is assumed that 90% of the operating cost is for gasoline.
- It is assumed that the average price of fuel is 55 cents per gallon.

$21,953 x 0.9 ÷ $0.55 = 35,923 gallons

(3) Summary of Additional Indirect Cost and of Wasted Gasoline:

a. Indirect Cost:

Passenger Cars, Operation	$107,504
Commercial Vehicles, Operation	21,953
Passenger Cars, Lost Time	52,725
Commercial Vehicles, Lost Time	10,109
Total:	$192,291

b. Wasted Gasoline:

Passenger Cars	175,916 gallons
Commercial Vehicles	35,923
Total:	211,839 gallons

2. Mohegan-Pequot Bridge Toll Station, 1975

A. Basic Data.

(1) Traffic:

Passenger Cars	2,859,894	
Commercial Vehicles	81,721	
Total:	2,941,615	
(2) Gross Revenue:	$319,982	$319,982
(3) Expenditures:		
a. Operational Costs:		
Personnel	$266,439	
Contract Services	28,099	
Supplies	8,719	
Subtotal:	$303,257	
b. Maintenance Cost:		
Personnel	$ 6,002	
Contract Services	192	
Supplies	736	
Subtotal:	$ 6,930	
TOTAL EXPENDITURES:		$310,187
(4) Net Revenue:		$ 9,795

B. Analysis of Indirect Costs to the Public.

(1) Passenger Cars:

a. Costs Per Vehicle Stop From 45 MPH:

Operation	2.0 cents
Lost Time	1.14 cents
Total:	3.14 cents

b. Calculation of Indirect Cost:

Operation: 2,859,894 stops x $0.02 =	$57,198
Lost Time: 2,859,894 stops x $0.0114 =	32,603
Total Indirect Cost:	$89,801

c. Calculation of Gasoline Wasted in Stopping:

- It is assumed that 90% of the operating cost is for gasoline.
- It is assumed that the average price of gasoline is 55 cents per gallon.

$57,198 x 0.9 ÷ $0.55 = 93,596 gallons

(2) Commercial Vehicles:

a. Costs Per Vehicle Stop From 45 MPH:

Operation	6.01 cents
Lost Time	3.15 cents
Total:	9.16 cents

b. Calculation of Indirect Cost:

Operation:	81,721 stops x $0.061 =	$4,911
Lost Time:	81,721 stops x $0.0315 =	2,574
Total Indirect Cost:		$7,485

c. Calculation of Gasoline Wasted in Stopping:

- For purposes of estimation, all commercial vehicles are assumed to be fueled by gasoline.
- It is assumed that 90% of the operating cost is for gasoline.
- It is assumed that the average price of gasoline is 55 cents per gallon.

$4,911 x 0.9 ÷ $0.55 = 8,036 gallons

(3) Summary of Additional Indirect Cost and of Wasted Fuel:

a. Indirect Cost:

Passenger Cars, Operation	$57,198
Commercial Vehicles, Operation	4,911
Passenger Cars, Lost Time	32,603
Commercial Vehicles, Lost Time	2,574
Total:	$97,286

b. Wasted Gasoline:

Passenger Cars	93,596 gallons
Commercial Vehicles	8,036
Total:	101,632 gallons